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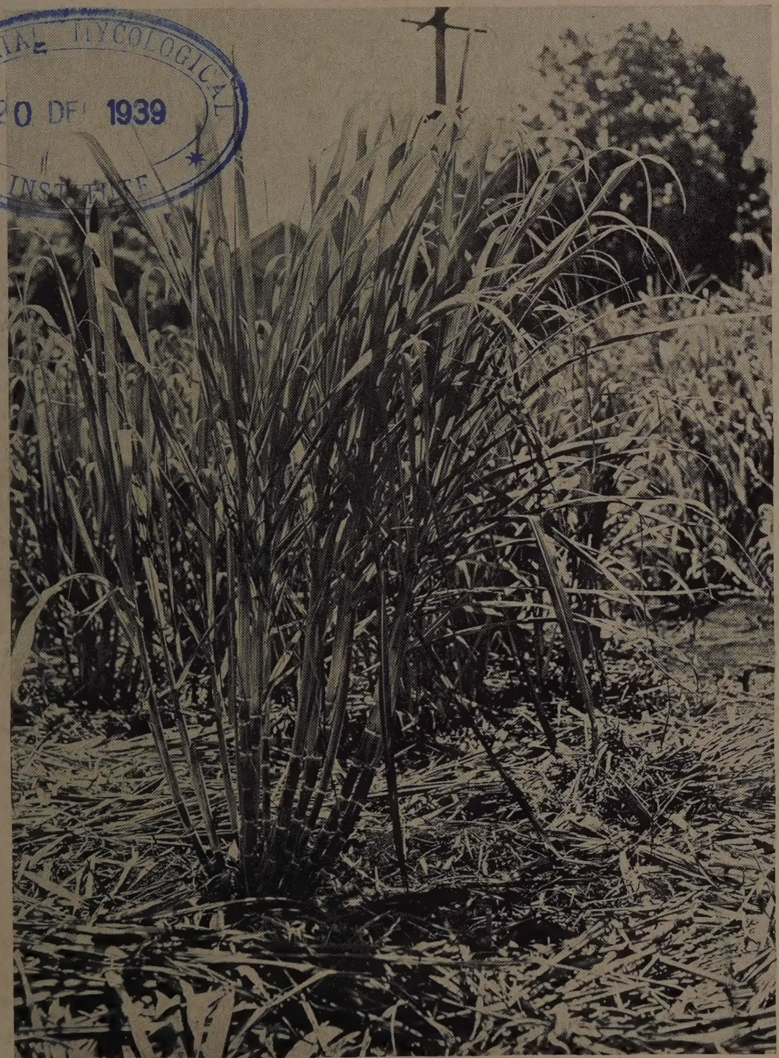
THE HAWAIIAN PLANTERS' RECORD



FIRST RATOON OF ORIGINAL STOOL OF 31–1389, FIELD 17, MAKIKI PLOTS, MARCH 18, 1932

From this stool 31–1389 was extended to over sixteen thousand acres within eight years.

FOURTH QUARTER 1939

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THE HAWAIIAN
PLANTERS' RECORD

Vol. XLIII FOURTH QUARTER 1939 No. 4

A quarterly paper devoted to the sugar interests of Hawaii and issued by the Experiment Station for circulation among the plantations of the Hawaiian Sugar Planters' Association.

In This Issue:

The Cane Variety 31–1389:

Germinated in 1931, the variety 31–1389 has been extended rapidly. It now occupies nearly twenty thousand acres. Although it is already being superseded by newer seedlings in some districts, it still commands interest in the districts to which it is best suited. The characteristics of this variety are examined in a series of five papers which deal with its origin, its adaptability to various climatic conditions, its reaction to diseases, its susceptibility to insect attack, its response to fertilizers, and its manufacturing qualities.

A Lysimeter Study of Losses of Applied Potash:

Potash applied to an acid soil in lysimeters suffered insignificant losses by leaching when the pots were cropped to cane. Uncropped pots suffered considerable losses through leaching. Ratoon cane appears to exhibit a high degree of efficiency in utilizing applied potash fertilizers.

The effective base-exchange capacity of the soil seems to play a very minor role compared with that of the cane crop in conserving applications of potash in fertilizers.

Disease Control and Stimulation of Cane Cuttings by the Hot-Water Treatment:

The subject matter in this article deals with the development of the hot-water treatment in relation to the control of chlorotic streak disease and the application of the treatment as a plantation practice for disease control as well as for stimulating the germination of sugar cane cuttings.

Evaporation of Moisture from Soil in Large Lysimeter Pots:

An experiment which required measurement of water applied and water leached from uncropped lysimeter pots indicated considerable losses of water by evaporation. These results are reported without comment.

31-1389—Its Origin and Present Status

By A. J. Mangelsdorf

Introduction

Even the best of our present varieties of sugar cane fall short of perfection. The perfect cane may be beyond our imagination, but we can set down some of the specifications for an improved variety in terms of the varieties with which we are familiar. Our hypothetical variety might, for example, combine such characteristics as:

1. The light tasseling, clean stalk, good milling qualities and eye spot resistance of Yellow Caledonia, without its weak ratooning.

2. The second-season growing power and high juice purity of H 109 without its eye spot susceptibility and slow starting.

3. The ratooning and weed suppressing power of POJ 36 without its slenderness and low sucrose content.

4. The high sucrose content of POJ 2878 without its boiling-house difficulties and excessive tasseling.

Such a list of specifications, while far from complete, serves to illustrate the fact that the desirable qualities are widely scattered among our present varieties. The objective of sugar cane breeding is to synthesize new canes which combine a maximum of the desirable qualities with a minimum of the undesirable qualities.

31–1389 may be regarded as one of the steps toward this objective. The purpose of this discussion is to record the history of 31–1389 and to attempt an evaluation of its desirable qualities and its faults, together with a consideration of their bearing upon its suitability for our various districts.

Propagation and Selection of 31–1389

31–1389 is the result of a cross between POJ 2878 and 26 C 270. The cross was set up at Kailua substation on November 29, 1930, under the supervision of J. N. P. Webster.

Because of its world-wide reputation there was naturally a strong interest in POJ 2878 as a breeding cane. The 1930–1931 crossing season gave us our first tassels of the "Java supercane." The lack of information as to the reaction of its tassels to the SO_2 solution led us to undertake a number of field crosses in which the POJ 2878 tassels used as females were allowed to remain growing on their own roots.

Tasseling stalks of the local varieties which were to serve as the male parents were cut and placed in the standard SO_2 solution. These cut tassels were then carried to the tasseling stools of POJ 2878 and supported in position so that their pollen would fall upon the tassels of POJ 2878.

The cross which produced 31–1389 was carried out in this manner. The tassels were harvested when ripe and germinated in the Makiki greenhouse. The germinating flat yielded 130 seedlings, which were set out in Makiki, Field 17, during April 1931 along with the seedlings from many other crosses.

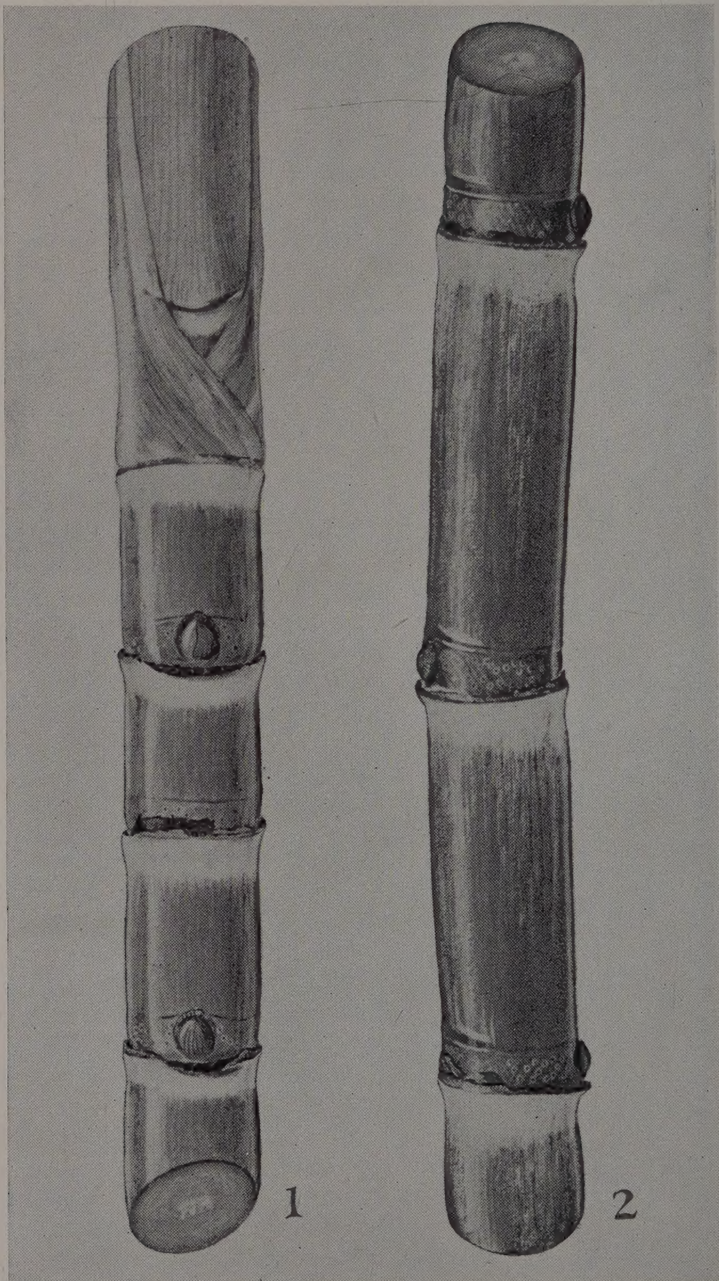


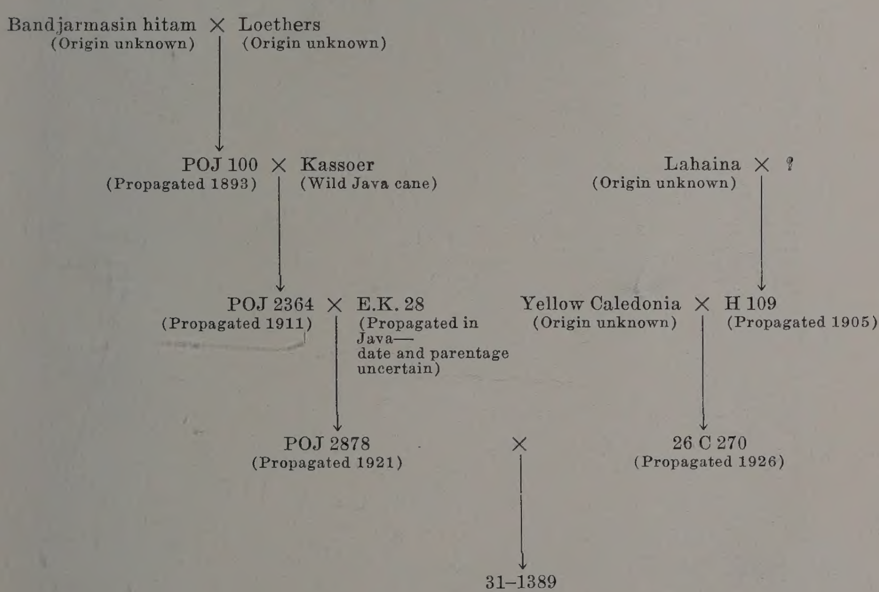
Fig. 1. Seedpieces of 31–1389. Front and side views showing extent of wax band.

The first selection of this group of seedlings was made by C. G. Lennox on September 28, 1931. The seedling which was to receive the number 31–1389 had six stalks, and a Brix of 14.5, which was above average for this field of young cane. It was given a grade of plus and was sent to the Kailua and Waipio stations for further testing.

The ratoon selection of this field was made on March 18, 1932, at which time the ratoon stool of 31–1389 was noted as double plus, with 17 stalks and a Brix of 15.8, which again was above average. J. A. Verret, Consulting Agriculturist of this Station, visited the field from time to time during the course of the selection. When Mr. Verret saw this stool he was so favorably impressed that he requested W. Twigg-Smith to make a photographic record of it. The photograph is reproduced on the cover of this issue.

The seed from the ratoon stool was sent to the Waipio, Kailua and Manoa stations for further testing and the extra body seed was sent to Kailua for spreading.

Pedigree of 31–1389



The pedigree of 31–1389 reveals its distinguished ancestry. Its mother and its maternal grandfather (E. K. 28) were the leading varieties of Java in their time. 26 C 270, the father of 31–1389, is the descendant of the three outstanding canes in Hawaiian sugar history. Lahaina was our leading variety until its failure during the early years of this century when it gave way to Yellow Caledonia, which held first place until 1924. In that year the Lahaina dynasty regained its leadership through the rise of H 109.

However, even the most distinguished of the ancestors of 31–1389 have their shortcomings, and some of its forbears are definitely mediocre by present standards. Unfortunately, 31–1389 has inherited some of the faults of its ancestors, along with many of their virtues.

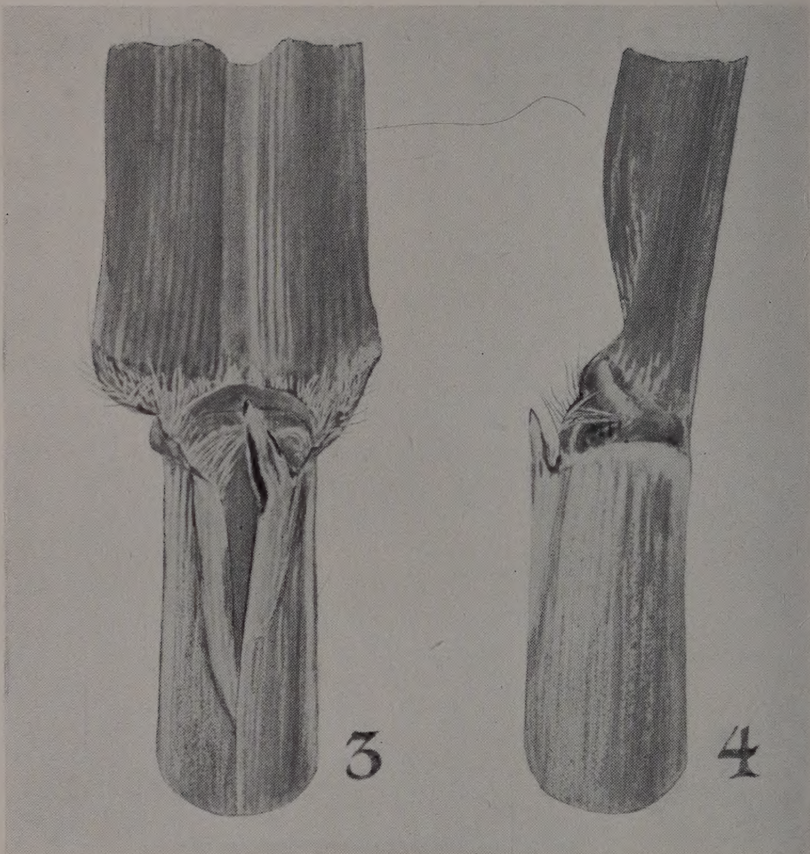


Fig. 2. Collar of 31–1389. Front and side views showing auricle and pubescence behind ligule.

Description of 31–1389

Slender at base, increasing in diameter in older cane, especially during late winter and spring. Average diameter larger than POJ 2878 and slightly smaller than H 109.

Rind very soft as young cane but tends to harden with maturity. Softer than H 109 but slightly harder than POJ 2878.

Color of young (unexposed) internodes, pale greenish-yellow.

Color of exposed internodes, yellow to brownish-yellow, sometimes tinged with green or russet.

Wax band narrow, conspicuous, more sharply defined than in POJ 2878 (Fig. 1).

Flesh color, as seen in cross section of internode, pale brownish-green or olive-green at rind, fading to nearly white at center.

Eyes plump, round, with well-defined wings. Hairing at apex of eye inconspicuous or absent as contrasted with the eyes of POJ 2878, the tips of which carry a tuft of hairs. Eye-groove absent (Fig. 3).

Root primordia usually three or four rows near eye, decreasing to two rows on opposite side of stalk.

Leaves pale green, often freckled, blades tending to curl backward toward midrib.

Hairing on back of leaf sheath (Group 57). Hairs fairly stiff and sharp but more or less appressed against leaf sheath. Hairing less formidable and much less extensive than on POJ 2878.

Joint triangle (dewlap) large, conspicuous, reddish in the younger leaves, inner surface downy pubescent. Auricle well developed on underlying edge of leaf sheath, absent on overlapping edge (Fig. 2).

Cultural Characteristics of 31–1389

Germination: The round prominent eyes of 31–1389 are easily damaged in handling. This is especially true of body seed from which the protecting leaf

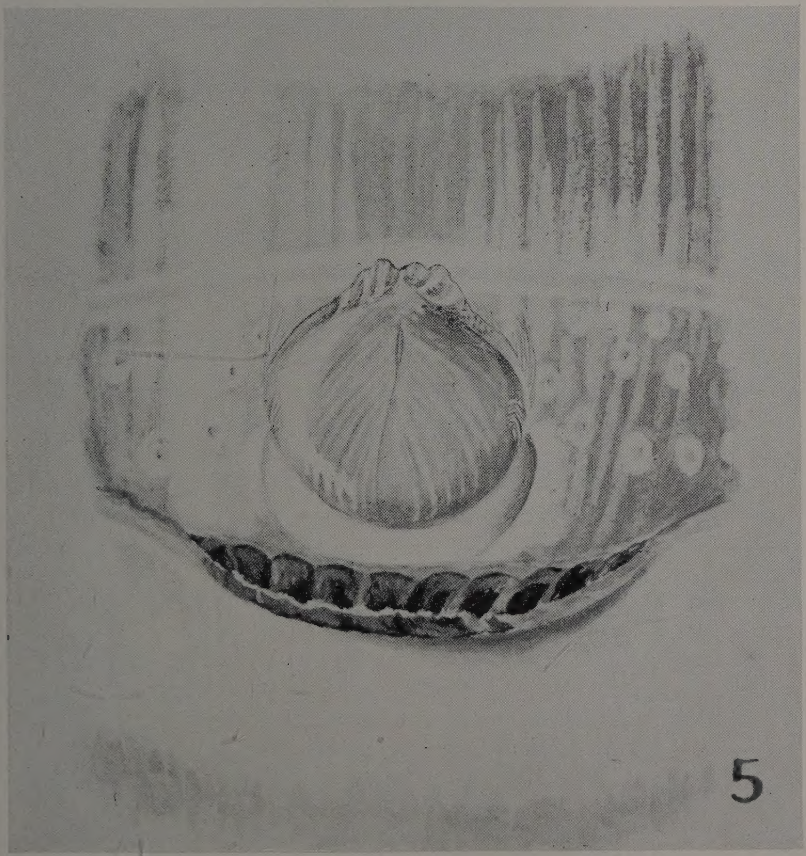


Fig. 3. Node of 31–1389 (enlarged) showing relative positions of leaf scar, eye and root primordia.

sheaths have been removed. Poor germination has frequently been experienced from stripped body seed handled in bags.

Several plantations have reported a reduction in damage to eyes when body seed is handled in bundles.

Unstripped top seed can be handled without special precaution, since the eyes are well protected by the overlying leaf sheaths.

Ratooning: As a fast starter in ratoons 31–1389 is one of the best. However, there is some difference of opinion as to its ability to maintain yields in ratoons. In some cases ratoon yields have been disappointing—in other cases yields have improved in ratoons.

Lack of soil aeration often limits ratoon yields in tight, poorly drained soils and in soils which pack badly. In such soils the plant crop is benefited by the improvement in aeration which results from plowing. However, the heavy soils tends to relapse quickly to a compact condition as a result of irrigation and of packing by heavy equipment, especially if harvested in wet weather. Under such conditions the ratoon yields of all varieties are likely to decline badly as compared with the plant crop. 31–1389 is no exception to this rule.

We have tallied the data from 62 replicated tests for which both plant crop and first ratoon data are available.

In 30 of the 62 tests 31–1389 improved its relative standing in first ratoons as compared with its plant crop standing. In 31 tests it compared less favorably in first ratoons than in plant. In one test there was no change in its relative standing in plant and first ratoons.

From the above it appears that 31–1389 is on the whole neither better nor worse in ability to maintain its yield in first ratoons than the standard varieties with which it was compared.

Wailuku reports that unlike POJ 2878, 31–1389 maintains a good stalk diameter in ratoons.

Closing-in: 31–1389 is outstanding as a fast starter. It develops its secondary shoots early and in abundance. Few varieties can equal it for fast closing-in. This is especially true under the makai conditions to which it is best suited.

As young cane it has an erect habit which together with its curving leaves makes it an excellent variety for mechanical cultivation.

Even in situations like the upper lands of the Hilo Coast and of Windward Kauai, to which it is not well suited, its early growth is rapid. Under these conditions, however, the stalk population is sparse and the crop tends to become open after going down.

Reaction to Environment: 31–1389 is at its best in the porous, fluffy, residual soils, and in the well-drained, gravelly alluvial soils. When grown on tight, poorly drained, and poorly aerated soils it may be benefited by sub-soiling, if the operation can be done under dry conditions immediately after harvesting.

31–1389 is inferior to H 109 in salt tolerance. At Ewa, at Waianae, and in the Kekaha flats, where the irrigation water is saline it has failed to outyield H 109. Its characteristic leaf freckle is aggravated under these conditions, which suggests that the freckle may be caused by an excessive intake of one or more of the salts which occur in abundance in such soils, or by a lack of availability of some essential element under the prevailing alkaline conditions.

Its drought resistance is better than average. Under severe drought it has shown more windburn than POJ 2878, but it makes a faster recovery after the moisture supply has been replenished. In the drought-resistance tests at the Waipio and Kailua substations it is among the leaders.

Its leaves are easily shredded by wind, but it is nevertheless a strong competitor in such windy situations as the makai lands of Hamakua, Kohala, Olowalu, and Central Maui.

31–1389 is typically a makai cane. Under mauka conditions it is usually pale and anaemic in appearance. In spite of its poor appearance it has occasionally given a good account of itself under middle-belt and mauka conditions. It has yielded well at 1000 feet in the Hamakua District and is a strong competitor in the mauka lands of Oahu Sugar Company.

Tasseling: 31–1389 may be classed as a medium tasseler. Counts from adjoining plots have shown lower tasseling percentages for 31–1389 than for POJ 2878. The following figures are typical:

Kaeleku Sugar Company, Ltd., age 8 months.

	No. counted	Per cent tasseled
31–1389	500	4
POJ 2878	500	27
31–1389	1000	18
POJ 2878	1000	41

As mature cane, 31–1389 usually tassels somewhat less than adjoining H 109 of the same age. However, when started in April or May, H 109 because of its slowness in the early stages may still be too small to tassel in November and December, while 31–1389 is likely to produce an occasional tassel.

Under sunny makai conditions the tasseled stalks of 31–1389 develop strong lalas which contribute materially to the tonnage at harvest. Under cloudy windward mauka conditions the lalas are slower and the weaker stalks may die through failure to develop lalas. The pithiness which develops after tasseling is more extensive than in H 109 but less than in POJ 2878.

Harvesting Characteristics: Because of its good stalk size, soft rind, and easy stripping 31–1389 is a desirable cane for harvesting by hand. For mechanical harvesting it has the advantage of good anchorage, the stools being less inclined to uproot than H 109, thus requiring less replant in the following crop.

McBryde reports that 31–1389 involves more pickup after rake harvesting since the stalks tend to break off several feet above the base. It is felt, however, that this fault is less costly than the uprooting and consequent heavy replant encountered in H 109.

Optimum Crop Length: The growth curve of 31–1389 differs from that of H 109. 31–1389 grows rapidly during the first season and slows down during the second season. H 109 is slow in getting under way, but it gains momentum during the second season. Under comparable conditions 31–1389 will attain in 18 to 20 months the tonnage and maturity characteristic of H 109 at 22 to 24 months.

The rind of 31–1389 is softer than that of H 109 and the stalks are more liable to injury and deterioration. 31–1389 is attractive to rats, and is likely to suffer serious damage in the presence of a large rat population. All of these features

point to shorter cropping cycles for 31–1389 than for canes like H 109 and Yellow Caledonia.

An examination of the data from replicated tests shows that 31–1389 is fairly flexible in respect to crop length. At Lihue it has given good results when harvested at 12 months. At Hawaiian Commercial and Sugar it held its own with H 109 at 26 months. In general, however, it may be said that 31–1389 may be successfully carried beyond 20 months only in the dry, sunny, well-drained situations. In the moist cloudy districts it must be harvested at 18 months or less for best results.

Juice Quality: Forty-nine replicated tests have been harvested to date comparing 31–1389 with H 109.

The average juice figures from these tests are tabulated below:

	Brix	Pol	Purity	Y%C	Q.R.
31–1389	18.5	15.5	83.9	11.30	8.85
H 109	17.9	15.4	86.1	11.46	8.73

It will be noted that 31–1389 averages higher in Brix and lower in purity than H 109 with little difference in the average quality ratios of the two canes. In this respect 31–1389 resembles its mother, POJ 2878, which shows a similar Brix-purity relationship.

It is encouraging to note that 31–1389 was nearly equal to H 109 in average quality ratio in spite of the fact that the tests were carried out under the fertilizer practices and crop lengths which have been adopted for H 109. It is reasonable to expect that an improvement in the juice quality of 31–1389 will result from a better understanding of its requirements.

The juice quality of 31–1389 is not equal to that of POJ 2878 when the Java cane is at its best, but when POJ 2878 has produced a heavy crop of suckers after tasseling its juices are frequently poorer than those of 31–1389. On the whole 31–1389 is average in juice quality. Very good or very poor juices are seldom encountered.

Distribution of 31–1389

31–1389 made its appearance just as the first regional variety stations were getting under way. Prior to that time the absence of regional stations necessitated sending new seedlings of promise to the plantations for their preliminary testing. During the transition period this practice was continued to the extent of distributing to the plantations seedlings which appeared outstanding without waiting for what we now regard as essential data from preliminary tests at the regional stations.

Such was the case with 31–1389. Its remarkable growth at Makiki, Kailua, and Waipio attracted immediate attention. In 1932, less than two years after germination, it was distributed to four plantations for further study. In 1933, it was sent to 24 plantations. Its appearance in these early plantings was so encouraging that by March 1934, within three years of the date on which it was transplanted from a pot into the field, it had been distributed to every plantation in the Territory.

Honolulu Plantation Company was the first to plant 31–1389 in a replicated variety test, and it was also the first to spread the new cane to field-scale plantings. H 109 and POJ 2878 were the leading varieties on this plantation at the time. Neither of these canes had proved entirely satisfactory. The slowness of H 109 as young cane resulted in high weeding costs. POJ 2878 gave good returns in the plant crop but declined in ratoons. The management was keenly interested in find-

ing a better variety for the plantation and pursued a vigorous testing program with this object in view. By the end of 1934, 31–1389 had been spread to 200 acres at Aiea. In 1935, 807 acres were planted and in 1936, 401 acres. By 1937 the area of 31–1389 at Honolulu Plantation Company had reached a total of 1777 acres.

During this time 31–1389 was being tested and spread to field areas on other plantations as well. In 1934, 6 replicated tests were installed to compare the new cane with the standard varieties. In 1935, 27 tests were installed and in 1936, 39 tests.

The increase in the acreage of 31–1389 on each of the four Islands from 1931 to 1938 is shown in the following table:

	Acreage of 31–1389 (1933 to 1938)					
	1933	1934	1935	1936	1937	1938
Kauai	0	60	763	2036	2745	3784
Oahu	1	286	1641	2628	4161	6325
Maui	0	92	493	1573	2490	3169
Hawaii	0	0	61	452	1757	3633
Total for Territory	1	438	2958	6689	11,153	16,911

It is of interest to compare the rate of increase of 31–1389 with that of H 109. Germinated in 1905, H 109 first appears in the acreage census of 1914, with 26 acres. In eight years 31–1389 has reached an acreage as large as that attained by H 109 in fifteen years.

The acreage of 31–1389 as of December 31, 1938 is shown below. Only plantations with one hundred acres or more are listed.

Plantation	Acreage of 31–1389 as of December 31, 1938	Per cent of total cane area on plantation
Kilauea	560	15.4
Lihue	1553	10.8
Grove Farm	433	13.0
McBryde	825	16.0
Kekaha	282	4.0
Honolulu Plantation Co.	1752	34.9
Oahu Sugar Co.	824	7.3
Waialua	1293	13.1
Kahuku	895	19.5
Waimanalo	1528	56.1
Pioneer	998	10.0
Wailuku	1147	25.8
H. C. & S. Co.	218	1.6
M. A. Co.	309	3.7
Kaeleku	497	15.0
Kohala	1110	9.2
Paauhau	318	7.3
Kaiwiki	121	2.9
Hakalau	149	2.5
Honomu	883	29.2
Pepeekeo	483	12.7
Hilo	134	1.7
Hutchinson	100	2.0
Total for Territory	16,911	7.2

Performance of 31–1389

One hundred and five replicated tests comparing 31–1389 with other varieties have been harvested by the plantations to date. These have been reported in detail in the Director's Monthly Report and the figures will not be repeated here.

In considering the results it is well to remember that even tests which are well replicated and carefully harvested are subject to error if situated on variable land. We cannot hope to escape soil variability entirely, nor can we hope to escape entirely errors in harvesting and in juice sampling. In view of these sources of error, and in further view of the climatic differences from season to season, we shall have to expect occasional contradictions. At best the replicated test is a crude tool, but since we know of no better one it devolves upon us to use it intelligently and to safeguard it to the best of our ability against unnecessary error.

With the limitations of replicated tests in mind, we may proceed to a consideration of the results of the tests comparing 31–1389 with other canes.

KAUAI:

Kilauea—In seven harvestings of replicated tests 31–1389 was better than POJ 2878 four times, it was equal twice, and poorer once. 31–1389 has a decided advantage over POJ 2878 in fields which are subject to eye spot and in cycles which favor tasseling.

31–1389 does well at Kilauea only on the better makai lands. Under the poorer conditions it has been outyielded by 31–1322 and by 31–2447. Even under makai conditions it has recently lost to 31–2806 in one test and to 32–8560 in two tests. It seems doubtful whether 31–1389 can hold its own against these newer canes even under the best of Kilauea conditions.

Lihue—31–1389 has not distinguished itself in replicated tests at Lihue. It has lost in several tests to 28–2055 in the middle and upper lands, and 28–2055 has in turn been outyielded by 31–2806, 32–1063, and 32–8560. 31–1389 has also lost to 31–2482, 31–2510, 31–3243, and 32–8163 in one or more tests. It is obviously out of the running in the poorer, middle-belt and mauka lands.

Its field performance in the better lands, however, has been quite satisfactory. In several fields it has established new records in sugar per-acre-month.

Grove Farm—31–1389 has not been included in replicated tests on this plantation, but it has yielded well in field plantings on the better makai lands.

Kipu—31–1389 has not been tested in replicated experiments on this plantation. Field observations indicate that it is not suited to Kipu conditions.

McBryde—31–1389 appears in only one test where it has outyielded H 109 and has equalled POJ 2878. It is preferred to H 109 because of its faster closing-in and lower cultivation costs.

Kekaha—In the makai lands 31–1389 has lost repeatedly to 28–2055 and 28–3540. Judging from its performance under similar conditions elsewhere it may still have possibilities in the lower half of the mauka slopes.

OAHU:

Honolulu Plantation Company—As already mentioned this plantation was the first to adopt 31–1389 as a commercial cane. H 109 had been for many years the standard variety but it was not at its best under Aiea conditions. The superiority of 31–1389 from the standpoint of cultivation costs was obvious from the start and

no time was lost in spreading it to field-scale plantings. 31–1389 has since lost to 32–8560 in both plant and ratoons of a replicated test and the results of field harvestings also point to the superiority of the latter cane. 31–1389 may eventually be forced to give way to 32–8560 at Aiea.

Oahu Sugar Company—31–1389 has been compared with H 109 in 12 harvestings of replicated tests (including plant and ratoons). In five of these it outyielded H 109, in five the yields were approximately even, and in two harvestings H 109 outyielded 31–1389. In field performance 31–1389 has shown up to best advantage in the upper lands where the slow growth of H 109 is further aggravated by eye spot disease. In tests recently harvested 31–1389 has twice lost to 32–8560, once in the middle belt and again in a makai "island" field.

Ewa—In six harvestings, H 109 led four times, while 31–1389 barely equalled H 109 in the other two. 31–1389 is not regarded with favor at Ewa. This applies also to Waianae, where the conditions are similar.

Waialua—In nine harvestings of replicated tests (plant and ratoons) 31–1389 led H 109 five times, the two canes were practically even three times, while H 109 led only once. No tests have as yet been harvested at Waialua comparing 31–1389 with 32–8560, but from observation the latter cane is believed to be superior in yielding ability and is being spread in preference to 31–1389.

Kahuku—Seven harvestings comparing 31–1389 with H 109 have resulted in substantial gains for 31–1389 in every case. The superiority of 31–1389 over H 109 at Kahuku in weed control and in ratooning ability is striking.

Waimanalo—POJ 2878 has run a close race with 31–1389 in replicated tests, most of which, however, were harvested in a non-tasseling cycle favorable to POJ 2878. Field experience has shown that 31–1389 involves less risk in a heavy tasseling cycle. This is especially true in fields which suffer from eye spot disease. 31–1389 has replaced POJ 2878 in the majority of the Waimanalo fields.

MAUI:

Pioneer Mill Company—31–1389 has been tested chiefly against POJ 2878 and 28–2055. In eleven harvestings comparing POJ 2878 with 31–1389, the latter cane led six times, POJ 2878 led three times, twice their yields were even.

In ten harvestings comparing 31–1389 with 28–2055 at Pioneer, four favor 31–1389, two favor 28–2055, and four were even. 31–1389 is being used extensively in the Olowalu Section. Whether or not it will be able to establish itself in the mauka lands above the H 109 belt will depend upon its ability to compete with 32–8560 and 32–1063 under these conditions.

Wailuku—31–1389 has appeared in only two replicated tests, one against H 109 and the other against POJ 2878. In neither test was 31–1389 definitely superior. Except for its larger stalk it has little advantage over POJ 2878 in a non-tasseling cycle, but for harvesting during the first half of the year it involves less risk of heavy tasseling in the following crop. Because of this and because of its low cultivating costs as compared with H 109 it has been spread to over one-fourth of the total area at Wailuku.

H. C. & S. Co.—31–1389 has outyielded H 109 in two tests, but with low odds. It is more tolerant of the growth-failure spots than H 109, and is being spread in areas where H 109 is not at its best.

M. A. Co.—31–1389 has been included in four tests, only one of which showed a definite gain for 31–1389. In two tests it barely equalled H 109 and in one test in the Hamakuapoko Section it lost by a small margin to POJ 2878. It is considered approximately equal to H 109 in yielding ability and superior from the standpoint of cultivating costs.

Kaeleku—31–1389 has led POJ 2878 in three out of five harvestings. Here again 31–1389 has little advantage over POJ 2878 except in a cycle which permits the Java cane to tassel heavily.

HAWAII:

Kohala—Two out of seven harvestings favored POJ 2878, two favored 31–1389, and three were even. In the middle-belt, unirrigated lands both 31–1389 and POJ 2878 lost to 32–3575 by two tons of sugar. 31–1389 has been spread to 1100 acres in the makai irrigated lands as an alternate for POJ 2878, which already occupied 3000 acres on this plantation.

Honokaa—31–1389 equalled POJ 2878 in a single test. It is favorably regarded as a cane for the makai irrigated lands.

Paauhau—There have been no direct comparisons of 31–1389 and POJ 2878 in replicated tests at Paauhau, but 31–1389 is preferred because of its good field performance in the irrigated lands. However, 31–1389 may have to give way to 32–8560, which outyielded it by a large margin in a recently harvested preliminary test.

Hamakua Mill Company—31–1389 outyielded POJ 2878 in two out of three harvestings, the third showing no difference.

Kaiwiki Sugar Company—Seven harvestings have shown no consistent difference in the yielding ability of 31–1389 and POJ 2878.

Laupahoehoe—31–1389 outyielded Yellow Caledonia by a good margin in a makai test. In the high rainfall district, from Laupahoehoe to Olaa, 31–1389 must be harvested at 18 months of age or less to avoid the risk of excessive deterioration.

Hakalau—In two out of four harvestings 31–1389 came through with good gains over POJ 2878. The other two showed small gains for POJ 2878. Both canes have been outyielded by 31–2510. The latter cane merits further study as a short cropper for the makai lands of the Hilo Coast.

Honomu—31–1389 has been compared with POJ 2878 in a single test. In the plant crop POJ 2878 led by .7 TS/A, in first ratoons 31–1389 led by 1.0 TS/A. 31–1389 is preferred on the basis of its field performance under short cropping in the makai lands.

Pepeekeo—31–1389 outyielded Yellow Caledonia in both plant and first ratoons of a makai test. Its field performance under short cropping has been good.

Onomea—31–1389 was badly beaten by POJ 36 in a middle-belt test harvested at 25 months. Its soft stalk and recumbent habit disqualify it for long cropping in this wet district.

Hilo Sugar—In a test at 1100 feet 31–1389 led POJ 2878 in plant and lost in first ratoons. Neither cane can measure up to 32–1063 or 31–2484 under these mauka conditions.

Olaa—In one test in the Kapoho Section, 31–1389 outyielded Yellow Caledonia. In another test in the Pahoa Section it equalled Olaa 3117, but lost to 31–2207.

Hawaiian Agricultural Company—In the single test harvested thus far 31–1389 outyielded D 1135 but lost to UD 50. The test is situated in the middle-belt. According to present indications neither cane will be able to compete with 32–1063 and 32–8560.

Hutchinson—31–1389 lost to POJ 2878 in two out of six harvestings and barely held its own in the other four. Here again it seems likely that both canes will have to give way to 32–8560 which outyielded POJ 2878 by a large margin in a recently harvested test.

31–1389 as a Breeding Cane

During the past four years 31–1389 has been used extensively in crossing with the object of combining its desirable qualities with those of certain other canes. It has been crossed with seedlings of Uba and *spontaneum* derivation to incorporate tolerance for mauka conditions and with *robustum* derivatives to develop a harder rind.

Even our best breeding canes produce only a small percentage of seedlings sufficiently free of faults to warrant further testing. This holds true for crosses with 31–1389. However, the general level of the 31–1389 crosses is above average, and some of the 31–1389 seedlings now in the preliminary stages of testing appear to have commercial possibilities. A few are fully equal to 31–1389 in fast starting and abundant stooling. 31–1389 promises to be a useful stepping stone in sugar cane breeding.

Summary

The principal faults of 31–1389 are:

(1) A soft rind which results in deterioration under long cropping. This difficulty is aggravated by wet conditions.

(2) Poor fuel value of bagasse.

(3) Sensitiveness to poor drainage and lack of soil aeration.

(4) Sensitiveness to poor mauka soils, especially on the windward slopes.

(5) A prominent eye which is easily damaged in handling when exposed by removing the leaf sheath.

The desirable features of 31–1389 are:

(1) Fast starting, excellent stooling, good closing-in and strong ratooning, all of which should help to reduce cultivation costs.

(2) Good drought resistance, which should make for more effective use of irrigation water.

(3) A relatively low nitrogen requirement, which should result in reduced fertilizer costs.

(4) Resistance to eye spot disease and mosaic disease.

(5) Moderate tasseling.

(6) Easy cutting when harvested by hand.

(7) Strong anchorage for grab or rake harvesting.

Present status and future prospects of 31–1389:

(1) 31–1389 is not suited to the tight, saline soils of Kekaha, Ewa, and Waianae.

(2) It is not suited to the poor mauka lands of the unirrigated districts.

(3) It cannot hold up under long cropping in the Hilo District.

(4) It is barely equal to POJ 2878 as a short crop cane on a non-tasseling cycle.

(5) It is equal to or better than H 109:

- (*a*) in the makai lands of Kilauea, Lihue, and Grove Farm;
- (*b*) on residual slopes like those of McBryde, Aiea, Kahuku, and Wailuku;
- (*c*) on alluvial soils like those of Olowalu;
- (*d*) in the poorer fields of Central Maui;
- (*e*) in fields where H 109 suffers from eye spot;
- (*f*) under conditions of labor shortage, since 31–1389 suffers less than H 109 from unavoidable delay in weeding and irrigation.

(6) It is equal to or better than POJ 2878 in the makai irrigated lands of the Kohala and Hamakua districts.

(7) It has produced good yields in sugar per-acre-month as a short cropper in the makai lands of the Hilo District.

31–1389 was gaining rapidly in acreage in the districts to which it is suited until the advent of new canes like 32–8560. The latter cane is not equal to 31–1389 in the early stages, but the preliminary data have shown it to be a heavier yielder at harvest.

Many replicated tests comparing 31–1389 with the more recent canes are already under way. From the harvesting results it will be possible within the next year or two to form a more accurate opinion as to the future of 31–1389.

31-1389—Its Reaction to Cane Diseases

By J. P. Martin

Within the past five years the variety 31–1389 has been commercially grown under a wide range of environmental conditions throughout all the Islands and has been exposed in one locality or another to natural conditions most favorable for the development of each of the major diseases. During this period numerous field observations have been recorded regarding its reaction to disease. With the exception of a few specific instances, as later discussed, the variety 31–1389 has in general remained resistant to diseases and may be grouped with such varieties as D 1135 and Yellow Caledonia which have been outstanding in their tolerance to sugar cane diseases.

Before discussing the reaction of 31–1389 to the various diseases it might be well to review its parentage, which follows:

```
31–1389....... { POJ 2878
                 ×
                 26 C 270..... { Yel. Cal.
                                 ×
                                 H 109....... { Lahaina
                                                ×
                                                ?
```

It is also of interest to consider 31–1389 and its parent varieties in relation to the major diseases; this information is presented in tabular form:

	Varieties					
Major diseases	31–1389	POJ 2878	26 C 270	Yel. Cal.	H 109	Lahaina
Brown stripe	—	= —	= —	= —	—	
Chlorotic streak	=	= —		=	= +	
Eye spot	+ +	= —	+	+	—	—
Leaf scald	= +	+ +		= —	=	
Mosaic	+ +	+ +	+	+	=	—
Pythium root rot.....	+	+	=	+	+	— —

In the above table each variety has been considered separately in its reaction to each disease and is so indicated by the following symbols:

+ +	Very highly resistant
+	Highly resistant
= +	Moderately resistant
=	Average
= —	Moderately susceptible
—	Highly susceptible
— —	Very highly susceptible

Of the six varieties, Lahaina and H 109 have shown the greatest susceptibility to the major diseases while 31–1389 has shown the greatest resistance; the varieties Yellow Caledonia and POJ 2878 follow 31–1389 in their tolerance to the various diseases. It is interesting to compare the high degree of resistance of 31–1389 to specific diseases with the low degree of resistance to the same diseases of some of the other varieties entering into its parentage. The above gradings are based on field observations and disease resistance tests. Where no symbol is given in the table there is little or no available information regarding the reaction of the variety to disease.

From the first experiments, 31–1389 was found to be highly resistant to eye spot disease and its spread to those localities where the disease has repeatedly occurred has controlled eye spot and given greater protection to surrounding fields. The ultimate economic control of eye spot can only be accomplished by substituting resistant and high-sucrose varieties for the susceptible ones—the planting of 31–1389 has accomplished much toward this end.

According to our records no case of mosaic disease has been observed on 31–1389; its resistance is even better than that of POJ 2878 on which only two cases of the disease have been reported since it was introduced into the Territory in 1928.

The incidence of chlorotic streak in localities favorable for the disease has been moderate on 31–1389; field observations show it to be more resistant than POJ 2878 under similar environmental conditions.

On windward Kauai the incidence of brown stripe has been moderate to severe on 31–1389. In some instances the lesions have coalesced thus causing the older leaves to manifest a prematurely dried appearance. On Oahu the degree of brown stripe infection has not been serious while on Maui and Hawaii the disease has been of less importance.

A leaf spotting characterized by small, irregular, chlorotic markings which later assume a light brownish color is frequently noted on 31–1389. The spotting is most pronounced on the older leaves and no doubt interferes somewhat with the normal development of affected plants. Our studies to date indicate that the disease is due to some physiological cause; no organism has been associated with the spots. In nutrient solution studies this particular leaf spot failed to develop on 31–1389 when grown in solutions lacking each of the following elements: nitrogen, potassium, phosphorus, magnesium, calcium, sulphur, manganese, iron, and boron.

According to our field observations and resistance tests, 31–1389 has been placed in the group of canes resistant and tolerant to leaf scald disease. An occasional case of leaf scald disease has been observed on 31–1389. It should be mentioned, however, that an epidemic of leaf scald disease developed in one small planting of

31–1389 on Hawaii. With the exception of this one outbreak of leaf scald, the severity of the disease on 31–1389 has remained of minor importance.

The variety 31–1389 has been grown in districts where other varieties have been moderately to severely attacked by *Pythium* root rot but it has remained unaffected. A small amount of ratoon chlorosis has developed on 31–1389 but here again it has proved to be more tolerant than H 109. Ring spot at times appears on the older leaves of 31–1389 but this disease has been of little significance. No economic losses from pokkah boeng have occurred on 31–1389 but an occasional case of the disease has been noted on the variety.

Little or no losses have occurred on 31–1389 from red rot or red stripe disease. At the higher elevations, especially during the winter months, leaf freckle has appeared on the older leaves of 31–1389 but this leaf spotting has been less severe than on D 1135, POJ 36 and other varieties.

31-1389—Its Susceptibility to Insect Attack in Hawaii

By C. E. Pemberton

The variety 31–1389 has exhibited no special susceptibility to attack by any of the sugar cane insects in Hawaii. Fieldmen have noticed that it remains unusually free of cane aphis and coincident black sooty mold during seasons when other varieties in the same locality are so affected.

It is less damaged by beetle borer than the variety POJ 2878 and is at least equal to H 109 in this respect. Although the rind is softer than in H 109, the self-stripping habit and slower growth in the second season seem to give 31–1389 a better resistance to borer attack than other varieties equally soft.

31-1389—Its Response to Fertilizers

By R. J. Borden

An examination of the results of cooperative fertilizer tests which have been conducted on the variety 31–1389 indicates that this cane is probably a very economical and efficient user of plant food, especially of nitrogen.

Of the 38 harvest results which we have recorded from Grade A "Amounts-of-Nitrogen" tests on this cane variety, we nóte that in 30 cases no reliable gain in sugar yield was secured for amounts above the minimum application of nitrogen that was included in the test; hence in these cases it is impossible to tell just how little nitrogen would have produced the optimum sugar yields. But a study of the accompanying Table I, in which the pertinent results are summarized, will quite clearly indicate that this variety has not made efficient use of the larger applications (more than 200 pounds) of nitrogen to put "sugar in the stalk."

Two experiments comparing ammonium sulphate with nitrate of soda on 31–1389 at The Lihue Plantation Company, Ltd., and a similar test at Kekaha Sugar Company showed no differences in the effectiveness of these two nitrogen carriers.

An experiment at Pepeekeo Sugar Company, on the time to apply 175 pounds of N to this variety, indicated significantly greater cane yields (by 8.2 ± 1.7 T.C.A.) when 50 pounds was applied at 7 weeks, another 50 pounds at 4 months, and 75

pounds at 6 months than when the total application was completed at 4 months. The quality was not affected by the time of application. At Waipio substation, 150 pounds of nitrogen applied at 1½ months was as effective as when divided into three 50-pound doses and applied at 1½, 3½, and 8½ months.

Eleven "Amounts-of-Phosphate" experiments, all except one from the island of Kauai and installed on soils which have been considered as being deficient in available phosphoric acid, have failed to show any response to applications of phosphate fertilizer (see Table II).

From twenty "Amounts-of-Potash" experiments (summarized in Table III), most of which were located on soils which are considered to be deficient in available potash, we find only 7 cases in which there was any reliable response to potash fertilization. At Honomu Sugar Company, on a 14½-month ratoon crop harvested in August, there was a response only up to 125 pounds of K_2O per acre. At The Lihue Plantation Company a 20-month plant crop harvested in December, and its subsequent 16½-month ratoon cut in May, both responded to a 200-pound application—the maximum amount included in the test. However, in another test at The Lihue Plantation Company a plant crop cut at 18 months in July had shown no response, and the response on its subsequent ratoon which was cut at 19 months in February was only to 100 pounds per acre. At Grove Farm Company, a 19-month ratoon crop cut in March responded to only 100 pounds. At Kahuku Plantation Company a 16-month plant crop cut in July gave a response up to 200 pounds per acre, while its subsequent 19-month ratoon cut in February responded to only 100 pounds; in both this test and in the Grove Farm Company experiment, there was no effect from a difference in the time of applying the potash. At Waimanalo Sugar Company an indicated response to potash was not statistically verified.

If the conditions under which these fertilizer experiments have been conducted can be considered as generally representative of the areas where this variety is being grown, the results would indicate that plantation fertilizer practices which have been devised for other cane varieties may need some revision if best results are to be secured from the variety 31-1389.

TABLE I

SUMMARY OF GRADE A "AMOUNTS-OF-NITROGEN" TESTS CONDUCTED ON VARIETY 31–1389

Plantation	Expt. No.	Crop year	Month harvested	Age (mos.)	Amounts compared (℔)	Variables applied at ___ months	Optimum** T.S.A. secured from	From this optimum amount of nitrogen-yields secured T.C.A.	T.S.A.	℔ N per acre per month used	℔ N used per ton sugar
Kohala Sugar Co....	108 AN	1939	Feb.	18	75–125–175	7 and 8	125 ℔ N	79	8.0	7.0	15.6
" " " ...	109 AN	1939	Feb.	18	100–150–200	6 and 7	100 ℔ N*	82	7.8	5.6	12.8
Paauhau S. Plt. Co..	65 AN	1938	Sept.	16½	75–100–150	7	75 ℔ N*	53	6.8	4.5	11.0
Pepeekeo Sugar Co..	40 AN	1938	Aug.	16	75–125–175–225	2, 4 and 6	75 ℔ N*	52	5.8	4.7	12.9
Honomu Sugar Co...	60 AN	1937	June	15	75–125–175	4 and 5	125 ℔ N	45	5.3	8.3	23.6
" " " ..	60 AN(R)	1938	Oct.	16	75–125–175	3, 5 and 7	125 ℔ N	58	6.9	7.8	18.1
H. C. & S. Co.......	69 AN	1938	July	27	180–230–280	2, 5 and 6	180 ℔ N*	100	12.1	6.7	14.9
Kaeleku Sugar Co...	27 AN	1939	Feb.	15½	0–75–150	2, 4 and 7	75 ℔ N	56	4.8	4.8	15.6
" " " ..	26 AN(R)	1939	May	17	50–100–150	1, 3 and 5	150 ℔ N	71	5.3	8.8	28.3
Waipio Substation ..	21 AN	1937	June	18	100–150–200	2, 3 and 6	150 ℔ N	74	10.1	8.3	14.8
" " ..	21 AN(R)	1939	June	24	100–150–200	2, 4 and 9	100 ℔ N*	87	11.2	4.2	8.9
Waimanalo Sugar Co.	54 AN	1937	Sept.	14	150–200–250	1, 4 and 6	150 ℔ N*	52	6.2	9.3	24.2
" " "	54 AN(R)	1939	Jan.	16½	150–200–250	2, 4 and 5	150 ℔ N*	84	7.0	9.1	21.4
" " "	57 AN	1939	May	20	200–250–300	2 and 3	200 ℔ N*	80	9.7	10.0	20.6
Kahuku Plt. Co.....	68 AN	1936	Sept.	16	125–175–225	2 and 4	125 ℔ N*	90	7.7	7.8	16.2
" " "	68 AN(R)	1938	April	18½	125–175–225	2 and 7	125 ℔ N*	87	8.9	6.8	14.0
" " "	86 AN	1939	July	21½	106–169	6	106 ℔ N*	48	5.8	4.9	18.3
Honolulu Plt. Co.....	63 AN	1938	April	19	150–250–350	2, 3, 4 and 6	150 ℔ N*	109	11.2	7.9	13.4
" " "	64 AN	1938	Aug.	17	150–250–350	2, 4 and 6	150 ℔ N*	85	8.6	8.8	17.5
" " "	66 AN	1939	March	20½	150–250–350	2, 4, 6 and 7	150 ℔ N*	104	12.6	7.3	11.9
Kilauea S. Plt. Co...	205 AN	1938	March	20	125–175–225–275	2, 3, 4 and 6	125 ℔ N*	81	6.5	6.3	19.3
" " " ..	205 AN(R)	1939	June	15	125–175–225–275	1, 2, 3 and 5	125 ℔ N*	55	3.9	8.5	32.1
Grove Farm Co......	70 AN(R)	1939	April	19	100–200	2 and 5	100 ℔ N*	76	9.4	5.3	10.6
The Lihue Plt. Co...	140 AN	1936	Dec.	20	150–200–250	1 and 2	200 ℔ N	90	8.6	10.0	23.2
" " " " ..	140 AN(R)	1938	May	16½	150–200–250	3 and 5	150 ℔ N*	66	8.2	9.1	18.3
" " " " ..	152 AN	1937	June	22½	128–178–228	1 and 2	128 ℔ N*	76	10.3	5.7	12.4
" " " " ..	152 AN(R)	1939	March	20½	125–175–225	3	125 ℔ N*	79	9.5	6.1	13.2
" " " " ..	155 AN	1937	July	18½	150–200–250	3 and 6	150 ℔ N*	75	7.4	8.1	20.2
" " " " ..	155 AN(R)	1939	Feb.	19	163–213–263	3 and 4	163 ℔ N*	77	8.8	8.6	18.5
" " " " ..	166 AN	1937	Aug.	17	150–200–250	5 and 6	150 ℔ N*	73	6.7	8.8	22.4
" " " " ..	166 AN(R)	1939	Feb.	18	142–192–242	2	142 ℔ N*	80	9.8	7.9	14.5
" " " " ..	183 AN	1938	June	17	150–200–250	3 and 4	150 ℔ N*	73	7.5	8.8	20.0
Kekaha Sugar Co....	14 AN	1937	Oct.	17	160–200–240–280	4, 6 and 8	160 ℔ N*	83	8.5	9.4	18.8
" " " ...	14 AN(R)	1939	March	17	150–200–250	5, 7, 8 and 10	150 ℔ N*	84	9.0	8.8	17.0
Pioneer Mill Co.....	328 AN	1937	May	21½	100–200–250	2, 4, 5 and 7	100 ℔ N*	88	8.9	4.8	11.2
" " "	322 AN	1937	Dec.	20	150–200–250–300	3, 10 and 11	200 ℔ N	112	12.3	10.0	16.2
" " "	324 AN	1937	May	23½	150–200–250–300	3, 5, 8 and 10	150 ℔ N*	94	10.2	6.4	14.7
" " "	336 AN	1937	Dec.	17	156–208–250	8 and 9	156 ℔ N*	77	6.1	9.2	25.6

* The minimum amount used in the experiment.
(R) Ratoon crop.
** No significant gain in T.S.A. secured for greater amounts of N per acre.

TABLE II

SUMMARY OF GRADE A "AMOUNTS-OF-PHOSPHATE" TESTS CONDUCTED ON VARIETY 31–1389

Plantation	Expt. No.	Crop year	Month harvested	Age (mos.)	Amounts compared (lb)	Variables applied at ___ months	Optimum* T.S.A. secured from	From this optimum amount of phosphate yields secured T.C.A.	T.S.A
Pioneer Mill Co........	326	1937	May	22½	0–100–200–300	1	No P_2O_5	88	10.3
Grove Farm Co.........	65 (R)	1939	March	19	0–200	1 and 6	" "	76	8.5
Kilauea S. Plt. Co......	203 (R)	1939	June	15	0–100–200–300	1	" "	55	3.8
Lihue Plt. Co..........	141	1936	Dec.	20	0–125–250	At planting	" "	96	8.6
" " ".........	141 (R)	1938	May	16½	0–100–200	3	" "	64	8.0
" " ".........	154 (R)	1939	March	20	0–125–250	1	" "	77	9.8
" " ".........	157 (R)	1939	Feb.	19	0–125–250	1⅓	" "	78	9.2
" " ".........	184	1938	June	17	0–100–200	2	" "	69	7.2
" " ".........	195	1939	Feb.	19½	0–100–200	1⅔	" "	79	9.7
McBryde Sugar Co.....	42	1939	April	18	0–200	1⅓	" "	113	9.8
Waimanalo Sugar Co...	58	1939	June	14½	0–180	At planting	" "	61	5.2

* No significant gain in T.S.A. secured for greater amounts of P_2O_5 per acre.
(R) Ratoon crop.

TABLE III

SUMMARY OF GRADE A "AMOUNTS-OF-POTASH" TESTS CONDUCTED ON VARIETY 31-1389

Plantation	Expt. No.	Crop year	Month harvested	Age (mos.)	Amounts compared (lb)	Variables applied at ___ months	Optimum* T.S.A. secured from	From this optimum amount of potash yields secured T.C.A.	T.S.A.
Honomu Sugar Co......	59 (R)	1938	Aug.	14½	0–125–250–375	3, 5 and 7	125 lb K_2O	56	5.3
Pepeekeo Sugar Co.....	41	1938	Aug.	16	0–100–200–300	2, 4 and 6	No K_2O	58	5.7
Kaeleku Sugar Co......	28 (R)	1939	March	15	0–150–300	1, 3 and 6	" "	43	4.4
Pioneer Mill Co........	325	1937	May	22½	0–100–200–300	1	" "	95	10.4
" " ".......	345	1938	Feb.	18½	43–101	7	43 lb K_2O	102	8.1
Kahuku Plt. Co........	80	1937	July	16	0–100–200	1, 4	200 lb K_2O	44	4.1
" " ".......	80 (R)	1939	Feb.	19	0–100–200	2	100 lb K_2O	45	5.1
Grove Farm Co.........	66 (R)	1939	March	19	0–100–200	1	100 lb K_2O	73	8.4
Kilauea S. Plt. Co......	204	1938	March	20	0–125–250	1 and 5	No K_2O	65	5.5
" " ".....	204 (R)	1939	June	15	0–125–250	1	" "	55	3.5
Lihue Plt. Co.........	142	1936	Dec.	20	0–100–200	1	200 lb K_2O	102	9.3
" " ".........	142 (R)	1938	May	16½	0–100–200	3	200 lb K_2O	66	8.4
" " ".........	153	1937	July	23	0–100–200	1	No K_2O	80	11.3
" " ".........	153 (R)	1939	March	20	0–100–200	1	" "	78	9.7
" " ".........	156	1937	July	18	0–100–200	At planting	" "	70	6.6
" " ".........	156 (R)	1939	Feb.	19	0–100–200	1½	100 lb K_2O	79	9.5
" " ".........	185	1938	June	17	0–100–200	2 and 7	No K_2O	74	7.6
" " ".........	196	1939	Feb.	19½	0–100–200	1½	" "	80	10.0
McBryde Sugar Co.....	43	1939	April	18	0–100–200	2½	" "	112	9.3
Waimanalo S. Co.......	58	1939	June	14½	0–213	2 and 5	" "	61	5.2

* No significant gain in T.S.A. secured for greater amounts of K_2O per acre.
(R) Ratoon crop.

31-1389—Its Manufacturing Qualities

By W. L. McCleery

The year 1939 is the third year that questionnaires have been sent to the plantations asking for specific information on the manufacturing qualities of new cane varieties that are being harvested in appreciable quantities. Below is a summary of replies received to September 1, 1939 on variety 31–1389. The figures for acres to be harvested in 1939 are taken from the Genetics Department, "An Acreage Census of Cane Varieties for the Crops of 1938 and 1939," dated March 1939. The percentages of crops harvested are from the 1938 and 1937 "Annual Synopsis of Mill Data."

Hakalau:

1939: Acres to be harvested, 63. No report received to the date of this compilation.

Hilo:

1939: Acres to be harvested, 119. All factory qualities good, compared with the standard varieties POJ 36 and Yellow Caledonia; also less trash.

Honolulu:

1939: Acres for harvest, 1452. Cane ground mixed with other canes. No outstanding poor qualities.

1938: Was 43 per cent of crop. No poor qualities.

1937: Was 19 per cent of harvest. Reported good, except for bagasse steaming quality which was fair.

Honomu:

1939: Acres for harvest, 640. No report to this date.

Hutchinson:

1939: Acres for harvest, 37. No report.

Kaeleku:

1939: Acres for harvest, 453. Rated as fair in boiling house and poor in mill-feeding and bagasse-burning qualities, as compared with POJ 2878. Has less trash; also lower fiber.

1938: Was 8 per cent of harvest. Ground mixed.

1937: Was 10 per cent of harvest. Rated as fair; poor in mill-feeding.

Kahuku:

1939: Acres for harvest, 455. Rated good throughout. After grinding considerable quantities there appears to be no appreciable difference at the mill or boiling house as compared with H 109.

1937: Rated as fair on first runs from poorly drained land.

Kaiwiki:

1939: Acres for harvest, 55. Has slightly more trash than D 1135. Good milling quality and is fair as a steam producer and in the boiling house. Given general rating of good.

Kekaha:

1939: Acres for harvest, 215. No report.

1937: Rated as fair to poor throughout.

Kilauea:

1939: Acres for harvest, 417. Several 100 per cent runs expected. Report not received.

1938: Ground 14 per cent of this cane for year. While it was generally mixed with POJ 2878, there was no trouble encountered. Rated as good throughout.

1937: Was 5 per cent of harvest. Rated as good. Better than either POJ 2878 or Badila.

Kohala:

1939: Acres this year's harvest, 801. Ground mixed; no definite information. No opinions.

1938: Rated to be just as good as other varieties. Was 3 per cent of crop.

Lihue:

1939: Acres, including Grove Farm, 1523. No report.

1938: Was 10 per cent of crop. Was good at the mill but poor in steam quality. No opinions for boiling house as it was ground mixed with other canes.

1937: Was 7 per cent of crop. No opinions possible as it was mixed with too much field soil.

Maui Agric.:

1939: Acres for harvest, 216. No report.

McBryde:

1939: Acres for 1939 harvest, 248. Rated as fair throughout, but conditions were not normal for accurate judging.

1938 and 1937: Was 4 per cent of each crop. Rated fair-to-good, each year.

Oahu:

1939: Acres for 1939 season, 442. No report received.

1938: Was 3 per cent of crop. Ground mixed; no opinions.

1937: Was 1 per cent of crop. Preliminary indications were that it had fair mill-feeding and poor steaming qualities.

Paauhau:

1939: Acres for harvest, 153. Rated as good. Grinding rate is increased due to large stick and less trash. The fiber is lower and necessitates faster grinding to maintain steam and boiler draft adjustments. It has a high phosphate content which makes ample settling capacity needed, especially when cane is mechanically harvested.

Pepeekeo:

1939: Acres for harvest, 277. No report received.

Pioneer:

1939: Acres for harvest, 518. No report received.

1938 and 1937: Constituted 8 to 9 per cent of each year's harvest. Rated good to fair in most qualities, but poor as steam producer.

Waialua:

1939: Acres for harvest, 466. No report.

1938 and 1937: Constituted 6 and 4 per cent respectively of tonnage ground each year. Ground mixed so opinions preliminary. Indications were poor qualities throughout, especially as steam producer.

Waianae:

Very little of this cane for 1939 and in 1938. In 1937 a large field gave very poor qualities throughout the factory. This field was replanted with other cane.

Wailuku:

1939: Acres for harvest, 834. No report yet available.

1938: Was 20 per cent of harvest. No general opinion; had fair mill-feeding and poor steaming quality.

1937: Was 4 per cent of crop. Ground mixed with POJ 2878 in rainy weather and no differences were noted.

Waimanalo:

1939: Acres for harvest, 1161. Has replaced POJ 2878 as standard variety. Good factory qualities throughout. As with POJ 2878, to obtain sufficient steam, draft and furnace adjustments were necessary.

1937: Was 12 per cent of crop. Rated as satisfactory.

A Lysimeter Study of Losses of Applied Potash by Leaching From an Acid Soil

By P. L. Gow

Introduction

This experiment was designed as part of a project which has as its purpose the evaluation of probable injurious effects upon Hawaiian cane lands of long continued fertilization with acid-forming fertilizers such as sulfate of ammonia.

Other investigators working with greatly differing soil types, and crops in widely separated parts of the world have found marked deleterious effects resulting with soils receiving continued amendments of ammoniacal salts as fertilizers. No attempt is made herewith to present a review of the literature concerning this problem since an excellent review, together with an extensive bibliography has been presented by Morgan (7, p. 381) who summarized the results of previous investigators as follows:

> That fertilizer constituents supplying nitrogen as ammonium salts have an acid effect upon the soil is clearly established. In all cases where soil changes resulting from the use of such materials have been studied, one or more of the following phenomena were exhibited:
>
> *a*. Increase in hydrogen-ion concentration of the soil (decrease in pH).
>
> *b*. Increase in exchangeable hydrogen.
>
> *c*. Decrease in the exchangeable bases, especially calcium.
>
> *d*. Increase in easily soluble aluminum, iron or manganese.
>
> Except on soils containing large reserves of calcium carbonate, such as the heavily chalked soil at Rothamsted, England, these results are readily measured within a short time, when substantial annual applications are made.

Eckart (3), working with Makiki soil in lysimeters planted to cane, found that greater quantities of calcium were leached from sulfate of ammonia treatments than were leached where nitrate of soda was applied. Peck (8) conducted lysimeter experiments with an acid upland soil from Hawaii and a basic lowland soil from Kauai. The lysimeters were not cropped. More potash and calcium were leached from the acid soil when sulfate of ammonia was applied than where no fertilizer was used. More calcium, but not significantly more potash, was leached from the basic soil following application of ammonium sulfate.

In considering the results obtained by workers elsewhere and by Eckart and Peck with Hawaiian soils it may be unwise to assume without further studies that such effects are certain to occur in soils which are cropped to sugar cane. Hawaiian cane lands support perhaps the largest masses of vegetative growth that have ever been produced on cultivated fields, and these consist of a crop which appears to have extensive effects upon the soils supporting it. Unpublished soil pH studies made by the writer at this Experiment Station in connection with Project C–3 in 1930–31 indicate that sugar cane may act as a buffer to soil pH changes, and that where fertilizers have been applied which produce either increase or decrease of soil pH, the crop, as it develops, tends to restore the pH to a value approaching that of untreated soil. This proved especially true in cases where

the soil pH was depressed as a result of fertilization with mixtures containing ammonium salts. Perhaps further investigations will indicate that effects heretofore observed elsewhere with acid-forming fertilizers may not be so significant where cane crops are grown.

However, for the purposes of this investigation, it was tentatively assumed that all of the effects mentioned by Morgan (7) would occur in soils cropped to cane. The question then became: How serious will these effects be with respect to the continued ability of Hawaiian soils to support cane crops?

Theoretical applications of soil chemistry, together with certain practical knowledge of cane requirements, lead to the following considerations:

(a) Decrease in soil pH *per se* will probably exhibit no deleterious effect upon cane yields until a very low level is reached. It can not be predicted how low that level will be without further study, since workers with Hawaiian soils have not yet found an agricultural soil of sufficiently low pH to impair seriously cane yields. Ayres (2) obtained normal cane growth in pots with soil of pH as low as 4.6, which is considerably lower than that of any Hawaiian soils normally cropped to cane. Martin (6) found that cane made good growth in water cultures at pH 4.0, but that growth was greatly retarded at pH 3.0. It is doubtful that any Hawaiian soil could attain a pH below 4.0.

(b) Increase of exchangeable hydrogen means decrease in effective exchange capacity, since hydrogen ion is very tenaciously retained by soils against replacement by bases. Hence, the capacity of soils to take up and retain bases applied as fertilizer amendments against loss by leaching might be seriously impaired as the result of ammoniacal fertilization. This effect would be especially harmful in the case of potash which is applied extensively in cane cultivation and might result in considerable economic losses.

(c) Decrease in exchangeable bases might be serious, especially in the case of potash, provided the potash which was released were leached instead of being taken up by the crop. Decrease in exchange calcium might be undesirable if it resulted in lowering the calcium reserve to a level insufficient for crop needs, or if sufficient calcium were made available to impair the juice quality of the crop. On the other hand, it is probable that sufficient calcium could be supplied as fertilizer amendment to provide for proper calcium nutrition at quite reasonable cost. In some cases, decrease of exchange calcium to a level requiring small lime applications might result in better juice quality since the calcium supply could then be controlled. Magnesium could also be supplied, presumably at low cost, as fertilizer. It is worthy of note that forms-of-nitrogen experiments have not hitherto showed poorer juice quality due to excess calcium liberated by sulfate of ammonia.

(d) Increase in easily soluble aluminum might result in toxic effects, but such effects have not hitherto been felt in forms-of-nitrogen experiments. Increase in easily soluble iron and manganese would perhaps be desirable. Should iron and manganese supplies become depleted, small applications as fertilizer amendments would be possible.

All of these effects appear possibly deleterious to Hawaiian soils, but none appear dangerous at present, except, perhaps, a decrease in effective exchange

capacity and resultant inability of soils to retain applied potash against loss by leaching. It was therefore decided to study first potash losses by leaching, together with the possibility of obviating them by the use of a basic potash salt to promote absorption by that portion of the exchange complex which was occupied by hydrogen ion. The present experiment was designed with that object in view.

Potassium carbonate was selected as the basic salt of potash to be used. While the cost per unit of potash as carbonate is about three times that of the sulfate, there is reason to believe that sources of cheaper carbonate might be developed provided the value of its use as fertilizer could be demonstrated. Preliminary laboratory tests comparing potassium carbonate with potassium chloride indicated that the former salt caused very much greater uptake of potassium ion with acid soils, due to neutralization of the exchangeable hydrogen ion by the carbonate ion and removal by leaching as H_2CO_3 and by decomposition of the latter into CO_2 and water. In this way the soil acidity was utilized to promote the desired effect which it tended to prevent when neutral potash salts were applied.

Muriate of potash was selected as the neutral salt to be compared, since the presence of considerable quantities of sulfate ions was considered undesirable in view of the method which was proposed to be used for analysis of the leachates.

Experimental Procedure

A free-draining, acid Manoa soil of pH 5.3 was filled into cubical concrete lysimeters whose dimensions were 2 x 2 x 2 feet. The pots were heavily tarred with roofing asphalt to prevent leakage and were provided with a single drainage hole at the bottom. The bottom sloped from all sides to the drainage hole. Leachates were collected in specially constructed 5-gallon tins which were fitted with 1.5-inch openings to minimize evaporation.

The lysimeters were arranged in 4 rows of 9 pots each and were sunk to ground level. Between each set of 2 rows was a sunken concrete runway which served to allow collection of leachates. A layout of the experimental arrangement is given below:

LAYOUT OF EXPERIMENT

1	2	3	4	5	6	7	8	9
5	6	2	8	3	7	4	9	1
C	NV	C	NV	C	NV	C	NV	C
10	11	12	13	14	15	16	17	18
1	7	9	4	8	5	6	2	3
C	NV	NV	C	NV	C	NV	C	C
19	20	21	22	23	24	25	26	27
3	8	5	6	1	7	2	9	4
C	NV	C	NV	C	NV	C	NV	C
28	29	30	31	32	33	34	35	36
6	4	7	2	9	3	8	1	5
NV	C	NV	C	NV	C	NV	C	C

The upper numbers which run consecutively are pot numbers. The lower numbers are treatment numbers. The designations C and NV indicate whether the pot was planted to cane or was kept free of vegetation.

Fertilizer Treatments:

In addition to comparing the leaching losses of potassium carbonate and chloride, it was thought desirable to compare the effects of applying potash together with ammoniacal salts and of delaying application of potash until nitrification of the ammonium salts was completed. It appeared likely that, even though potash from the carbonate was forced into the base-exchange complex due to neutralization of exchange hydrogen, subsequent production of hydrogen ions by nitrification of ammonium salts might result in release of potash initially absorbed. Somewhat greater loss of potash from the muriate of potash treatments might also be expected from this cause. Experience of other workers had demonstrated that 45 days was ample to secure complete nitrification of ammonium salts in Manoa soils of the same type and originating from the same locality as the soil used in this experiment. Therefore it was decided to include carbonate and muriate of potash treatments in which potash application was withheld for 45 days after nitrogen was applied. Ammonium chloride instead of sulfate was used as nitrogen application for the same reason that the chloride of potassium was selected.

Treatments in which pots were kept free of vegetation were included, since it was considered essential, in view of previous experience, to determine whether the presence of a cane crop materially influenced the results.

In view of the fact that by far the greater proportion of Hawaiian cane crops are ratoon rather than plant crops, this experiment was conducted with ratoon cane. To secure uniformity of stand, four 3-eye cuttings of H 109 cane were planted in each of the 36 pots. After the shoots were well started, three of the cuttings were dug up and rejected, while two shoots from the third cutting were excised. Thus a quite uniform stand of cane was started, each pot containing one shoot attached to a 3-eye seedpiece. After the cane had been allowed to grow for four months with daily irrigation, the cane was cut at ground level in the pots to be ratooned and was cut back to the seedpiece in the no-vegetation pots. At this time enough stalk had developed in each pot to insure a vigorous ratoon crop. On July 5, 1938, fourteen days after harvest, the first application of fertilizer was made and collection of the first series of leachate samples begun. At this time all pots received nitrogen at the rate of 100 pounds N per acre as NH_4Cl. Previously, when the soil was filled into the pots, all pots had received 100 pounds N per acre and 369 pounds P_2O_5 as Ammo-phos 13–48.

Fertilizer applications were made in solution and were applied to an area one foot long and three inches wide on a line directly above the seedpiece. In the field, it is estimated that there normally occurs about one stool of cane per foot of line; counts made in experimental plots have indicated that about four fully grown stalks of cane per foot represent a heavy growth of cane. Cane growth was therefore limited to four stalks per pot. According to field practice in Hawaii, cane lines are spaced 5 feet apart, so each stool of cane averages about 5 square feet of surface. In this experiment each stool enjoyed only 4 square feet of surface, due to the size of the lysimeters. Each pot was considered as representing one running foot of line and a figure of 8712 running feet of line per acre was accepted as basis for calculation of fertilizer applications.

On July 5, at the same time that all treatments received nitrogen as ammonium chloride, the "potash-with-nitrogen" treatments received 300 pounds per acre of K_2O as either muriate or carbonate. Forty-five days later the "potash-after-nitrogen" treatments received a like amount of potash.

The various treatments were as follows:

Cane Treatments

1. No K_2O.
2. KCl with nitrogen.
3. K_2CO_3 with nitrogen.
4. KCl after nitrogen.
5. K_2CO_3 after nitrogen.

No-Vegetation Treatments

6. KCl with nitrogen.
7. K_2CO_3 with nitrogen.
8. KCl after nitrogen.
9. K_2CO_3 after nitrogen.

Irrigation:

In order to compare the cane treatments with the no-vegetation treatments, it was decided, instead of irrigating all pots alike, to apply water in such manner as to cause all pots to yield, as nearly as possible, the same amounts of leachate. This, of course, required an application of greater quantities of water to the cane pots than to the no-vegetation pots in order to compensate for the water consumed by the cane. The technic of irrigating to this end was developed during the time the plant crop was being grown to the point at which it could be safely ratooned. It was sought to make each pot approximate an average leaching of 3 liters per day which would be equivalent to 0.32 inch. The water consumption for each day of each pot, together with rainfall data, was used to calculate the required irrigation for the following day. Unfortunately, at the end of each 45-day sampling period, several days of rainy weather occurred which made it impossible to secure strictly comparable amounts of leachates for the two periods. The amounts of leachates from the various pots at the end of each period are fairly comparable (Table I). Irrigation was with tap water and each day a sample representing 3 liters was taken. The amounts of K_2O in the tap water given in Table I represent the summation of the amounts of K_2O in successive 3-liter per day portions taken over each 45-day period. The daily irrigations for each pot were weighed out by means of a solution balance.

Sampling:

The water leached from each lysimeter was collected in a 5-gallon tin can which was especially constructed to minimize evaporation and to exclude rainwater. Samples were usually collected every other day. However, in rainy weather it was necessary to sample daily and a few times, when conditions were favorable.

as much as 4 days' leachates were allowed to collect before sampling. The procedure followed in sampling was to weigh each can with the contained leachate, shake the can vigorously to insure uniformity of sample, take one-tenth of the leachate for analysis, empty the can and weigh the can again for tare.

Analysis of Leachates:

The leachate samples, representing one-tenth of the total leachate for each 45-day period, were evaporated on a hot plate and aliquots were taken for determination of K_2O. Potash was determined colorimetrically by the Hill method (5) as modified by Gow (4).

Discussion of Data

Table I shows the amount of K_2O leached from each pot during each of the 45-day periods, together with the total amount for the entire 90 days. The leachate sample from Pot 18, Series A, was lost so that the value given here is an estimated value calculated statistically by the method of Allan and Wishart (1).

Table II gives the mean for each series and for the total amounts of potash leached. Appended to Table II is a table showing the differences required for significance for each series. Since it was desired to compare the averages of Treatments 2 and 3 in Series A with 4 and 5 in Series B, and 6 and 7 in Series A with 8 and 9 in Series B, the required differences for these comparisons are also given in the column labeled "A and B."

Table III is presented to show that there were no significant differences due to position of pots between the various treatments.

In Table IV are given the means for the various treatments of the per cent of the applied K_2O which was leached. These values are calculated by subtracting mean amounts leached from the No-K_2O treatments in each series from the means for each of the other treatments, dividing by the amount of potash applied and multiplying by 100.

Table V-A lists the differences between the treatments within each series to facilitate comparison of the various average amounts leached.

In order to discover the effect of delaying application of potash until nitrification of ammonium salts is complete it is necessary to compare Treatments 1A, 2A, 3A, 4B, 5B, 6A, 7A, 8B and 9B since these represent the 45-day periods immediately following potash application. Table V-B gives the differences between these averages, which are not shown by Table V-A.

Cane Treatments:

Treatment 2 showed no significantly increased leaching over Treatment 1 during the first 45 days following application of potassium chloride together with ammonium sulfate. During the second 45-day period, however, an average of 0.88 gram more K_2O was leached from these pots than from the no-potash pots. A difference of 0.75 gram is required for odds of 19 to 1, so this increase is significant although not highly so. The mean loss from Treatment 2 for this period represented 5.7 per cent of the potash applied.

TABLE I

Soil pH = 5.3

Treatment	Pot No.	Inches water leached 1st set	Inches water leached 2nd set	Total inches water leached	Gms K_2O applied 1st set	Gms K_2O applied 2nd set	*A* Gms K_2O leached 1st period	*B* Gms K_2O leached 2nd period	*Total* Total gms K_2O leached
				CANE					
1—No K	9	16.51	14.15	30.66	0	0	.198	.560	.758
	10	16.11	13.98	30.09	0	0	.648	.508	1.16
	23	16.34	14.03	30.37	0	0	.436	.234	.670
	35	16.95	13.96	30.91	0	0	.468	.552	1.02
2—KCl with N	3	16.33	14.05	30.38	15.621	0	.198	.918	1.12
	17	17.68	13.79	31.47	15.621	0	.420	1.41	1.83
	25	16.59	14.08	30.67	15.621	0	.530	1.59	2.12
	31	17.62	14.49	32.11	15.621	0	.766	1.45	2.22
3—K_2CO_3 with N	5	16.80	14.17	30.97	15.621	0	.234	.560	.794
	18	17.01	14.17	31.18	15.621	0	.790	1.06	1.85
	19	16.89	14.12	31.01	15.621	0	1.15	.350	1.50
	33	16.52	14.10	30.62	15.621	0	.558	.666	1.22
4—KCl after N	7	16.66	14.10	30.76	0	15.621	.856	.650	1.51
	13	17.43	14.08	31.51	0	15.621	.582	.338	.920
	27	16.65	14.13	30.78	0	15.621	.380	.472	.852
	29	16.70	14.12	30.82	0	15.621	.464	.596	1.06
5—K_2CO_3 after N	1	16.73	14.10	30.83	0	15.621	.558	.540	1.10
	15	17.04	14.29	31.33	0	15.621	.348	.258	.606
	21	16.98	13.95	30.93	0	15.621	.400	.332	.732
	36	17.61	14.06	31.67	0	15.621	.624	.412	1.04
				NO VEGETATION					
6—KCl with N	2	16.76	14.36	31.12	15.621	0	3.26	3.12	6.38
	16	16.89	14.67	31.56	15.621	0	.958	3.44	4.40
	22	16.79	14.35	31.14	15.621	0	2.36	3.26	5.62
	28	16.54	14.31	30.85	15.621	0	2.66	5.16	7.82
7—K_2CO_3 with N	6	16.75	14.35	31.10	15.621	0	1.21	4.32	5.53
	11	16.71	14.35	31.06	15.621	0	4.18	3.58	7.76
	24	16.94	14.36	31.30	15.621	0	2.04	2.48	4.52
	30	17.39	14.36	31.75	15.621	0	.524	2.22	2.74
8—KCl after N	4	17.24	14.35	31.59	0	15.621	.852	1.48	2.33
	14	16.75	14.33	31.08	0	15.621	1.12	1.57	2.69
	20	17.10	14.37	31.47	0	15.621	.456	1.76	2.22
	34	16.45	14.34	30.79	0	15.621	1.28	1.39	2.67
9—K_2CO_3 after N	8	16.65	14.33	30.98	0	15.621	.310	.618	.928
	12	16.72	14.32	31.04	0	15.621	.390	.824	1.21
	26	16.67	14.33	31.00	0	15.621	.738	1.01	1.75
	32	17.08	14.36	31.44	0	15.621	.952	1.39	2.34
H_2O		Avg. 16.76	Avg. 14.22	Avg. 30.98			*.165	*.567	*.732

* These figures represent the grams K_2O originally present in the average amount of irrigation water which leached through the pots. They were obtained by calculating the potash content of the water samples taken for each period to the basis of inches water leached.

TABLE II

AVERAGE GRAMS K_2O LEACHED PER POT FROM EACH TREATMENT

Treatment No.	Treatment	Sample series A	Sample series B	Sample series Total
	CANE			
1	No K_2O	.44	.46	.90
2	KCl with N.........	.48	1.34	1.82
3	K_2CO_3 with N......	.68	.66	1.34
4	KCl after N........	.57	.52	1.09
5	K_2CO_3 after N......	.48	.39	.87
	NO VEGETATION			
6	KCl with N.........	2.31	3.75	6.06
7	K_2CO_3 with N......	1.99	3.15	5.14
8	KCl after N........	.93	1.55	2.48
9	K_2CO_3 after N......	.60	.96	1.56

Difference needed for significance	Series A	Series B	Series A & B*	Series Total
19 to 1.............	1.02	.75	1.01	1.34
99 to 1.............	1.39	1.02	1.37	1.82

* By Series A & B is meant a series made up of Treatments 1A (or 1B), 2A, 3A, 4B, 5B, 6A, 7A, 8B and 9B.

TABLE III

ANALYSIS OF DIFFERENCES BETWEEN TREATMENTS DUE TO LOCATION OF POTS

Series	"F" value Found	"F" value Required for significance
A	.12	3.01
B	.40	3.01
A & B...........	.17	3.01
Total	.18	3.01

TABLE IV

AVERAGE PER CENT K_2O APPLIED WHICH WAS LOST THROUGH LEACHING

Treatment No.	Treatment	Sample series A	Sample series B	Sample series Total
	CANE			
1	No K_2O	0	0	0
2	KCl with N.........	0.3	5.7	6.0
3	K_2CO_3 with N......	1.6	1.3	2.9
4	KCl after N........	0.9	0.4	1.3
5	K_2CO_3 after N......	0.3	—0.4	—0.1
	NO VEGETATION			
6	KCl with N.........	12.0	21.1	33.1
7	K_2CO_3 with N......	9.9	17.3	27.2
8	KCl after N........	3.2	7.0	10.2
9	K_2CO_3 after N......	1.0	3.2	4.2

Per cent K_2O applied which was leached =

$$\frac{\text{Grams } K_2O \text{ leached} - \text{Grams } K_2O \text{ leached from No-}K_2O \text{ pots}}{\text{Grams } K_2O \text{ applied}} (100)$$

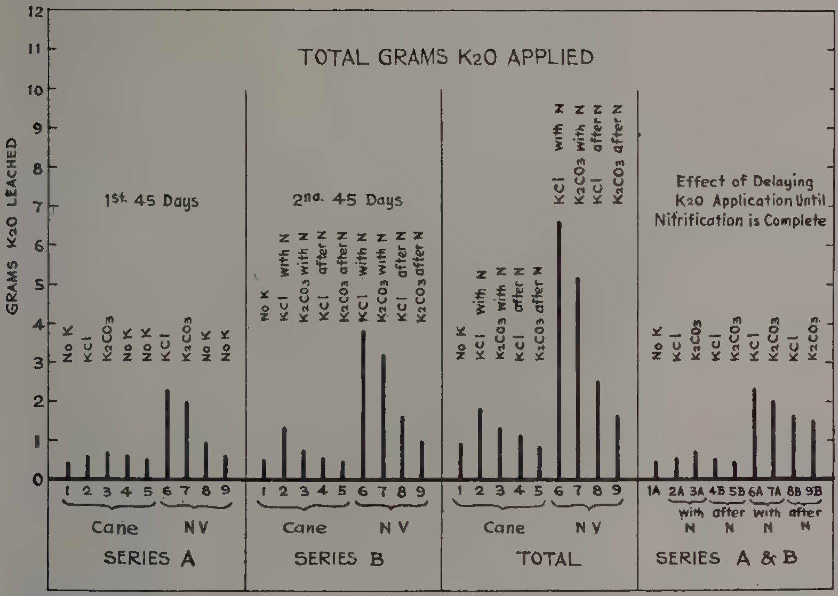


Fig. 1. Graphical comparison of amounts of potash leached from the various treatments.

The difference between the total amount of potash leached over the entire 90 days from Treatment 2 and that from Treatment 1 is 0.92 gram, which is considerably less than the amount required (1.34 grams) and is therefore not a reliable difference. However, the fact that the loss of potash from Treatment-2 pots during the second 45 days was significant indicates that more trust can be put in the total loss of 6.0 per cent of applied potash than is indicated by the statistical analysis of the totals alone.

Differences between Treatments 3 and 2 are not proved to be significant. However, neither are differences between Treatments 3 and 1, but between 2B and 1B they are reliable. In view of these facts and in consideration of the amounts leached from each treatment, the carbonate does not appear to offer much greater conservation of potash than does the chloride when applied to soil cropped to cane, although the data suggest that further experiments would continue to show somewhat smaller losses from potassium carbonate.

We are not justified in comparing Treatments 2 and 3 with 4 and 5 in the B series, since, when this set of samples was started, Treatments 2 and 3 had already had potash for 45 days, while Treatments 4 and 5 had just received potash. Had sampling from Treatments 4 and 5 been continued for an additional 45 days, further losses of potash due to treatment might have occurred as was the case during the second period with Treatment 2. No significant differences are found between 4B and 2A, or 5B and 3A, so delaying application of potash until after nitrification was complete did not appear to result in lower potash losses.

In general, it can be said that potash losses were so small as to be unimportant when potash was applied to pots containing a ratoon cane crop and that the effects of varying treatment were negligible.

TABLE V-A

DIFFERENCES BETWEEN TREATMENTS IN GRAMS

Treatment	Sample series	Treatments 1	2	3	4	5	6	7	8	9	Difference required 19:1	99:1
CANE												
1—No K_2O	A	....	.04	.24	.13	.04	**1.87**	**1.55**	.49	.16	1.02	1.39
	B	....	**.88**	.20	.06	.07	**3.29**	**2.69**	**1.09**	.50	.75	1.02
	Total	....	.92	.44	.19	.03	**5.16**	**4.24**	**1.58**	.66	1.34	1.82
2—KCl with N.......	A	.04	....	.20	.09	0.00	**1.83**	**1.51**	.45	.12	1.02	1.39
	B	**.88**	....	.68	**.82**	**.95**	**2.41**	**1.81**	.21	.38	.75	1.02
	Total	.92	....	.48	.73	.95	**4.24**	**3.32**	.66	.26	1.34	1.82
3—K_2CO_3 with N.....	A	.24	.20	....	.11	.20	**1.63**	**1.31**	.25	.08	1.02	1.39
	B	.20	.68	....	.14	.27	**3.09**	**2.49**	**.89**	.30	.75	1.02
	Total	.44	.48	....	.25	.47	**4.72**	**3.80**	1.14	.22	1.34	1.82
4—KCl after N.......	A	.13	.09	.11	....	.09	**1.74**	**1.42**	.36	.03	1.02	1.39
	B	.06	**.82**	.14	....	.13	**3.23**	**2.63**	**1.03**	.44	.75	1.02
	Total	.19	.73	.25	....	.22	**4.97**	**4.05**	**1.39**	.47	1.34	1.82
5—K_2CO_3 after N....	A	.04	0.00	.20	.09	....	**1.83**	**1.51**	.45	.12	1.02	1.39
	B	.07	**.95**	.27	.13	....	**3.36**	**2.76**	**1.16**	.57	.75	1.02
	Total	.03	.95	.47	.22	....	**5.19**	**4.27**	**1.61**	.69	1.34	1.82
NO VEGETATION												
6—KCl with N.......	A	**1.87**	**1.83**	**1.63**	**1.74**	**1.83**	....	.32	**1.38**	**1.71**	1.02	1.39
	B	**3.29**	**2.41**	**3.09**	**3.23**	**3.36**	....	.60	**2.20**	**2.79**	.75	1.02
	Total	**5.16**	**4.24**	**4.72**	**4.97**	**5.19**	....	.92	**3.58**	**4.50**	1.34	1.82
7—K_2CO_3 with N.....	A	**1.55**	**1.51**	**1.31**	**1.42**	**1.51**	.32	....	**1.06**	**1.39**	1.02	1.39
	B	**2.69**	**1.81**	**2.49**	**2.63**	**2.76**	.60	....	**1.60**	**2.19**	.75	1.02
	Total	**4.24**	**3.32**	**3.80**	**4.05**	**4.27**	.92	....	**2.66**	**3.58**	1.34	1.82
8—KCl after N.......	A	.49	.45	.25	.36	.45	**1.38**	**1.06**	....	.33	1.02	1.39
	B	**1.09**	.21	**.89**	**1.03**	**1.16**	**2.20**	**1.60**	....	.59	.75	1.02
	Total	**1.58**	.66	1.14	**1.39**	**1.61**	**3.58**	**2.66**	....	.92	1.34	1.82
9—K_2CO_3 after N....	A	.16	.12	.08	.03	.12	**1.71**	**1.39**	.33	....	1.02	1.39
	B	.50	.38	.30	.44	.57	**2.79**	**2.19**	.59	....	.75	1.02
	Total	.66	.26	.22	.47	.69	**4.50**	**3.58**	.92	....	1.34	1.82

Differences in bold-face type are great enough for significance.

TABLE V–B

DIFFERENCES BETWEEN TREATMENTS IN GRAMS

Treatment	Sample series	Treatments 1 A	2 A	3 A	4 B	5 B	6 A	7 A	8 B	9 B
				CANE						
1—No K_2O	A	....	.04	.24	.08	.05	**1.87**	**1.55**	**1.11**	.52
2—KCl with N......	A	.04	....	.20	.04	.09	**1.83**	**1.51**	**1.07**	.48
3—K_2CO_3 with N....	A	.24	.20	....	.16	.29	**1.63**	**1.31**	.87	.28
4—KCl after N......	B	.08	.04	.16	....	.13	**1.79**	**1.47**	**1.03**	.44
5—K_2CO_3 after N...	B	.05	.09	.29	.13	....	**1.74**	**1.60**	**1.16**	.57
				NO VEGETATION						
6—KCl with N......	A	**1.87**	**1.83**	**1.63**	**1.79**	**1.74**	....	.32	.76	**1.35**
7—K_2CO_3 with N....	A	**1.55**	**1.51**	**1.31**	**1.47**	**1.60**	.32	....	.44	**1.03**
8—KCl after N......	B	**1.11**	**1.07**	.87	**1.03**	**1.16**	.76	.44	....	.59
9—K_2CO_3 after N...	B	.52	.48	.28	.44	.57	**1.35**	**1.03**	.59	....

Difference required: 19:1 = 1.01 grams
99:1 = 1.37 grams.

Differences in bold-face type are great enough for significance.

No-Vegetation Treatments:

During the first 45-day period, Treatment 6 lost an average of 1.38 grams more than Treatment 8, which was the no-vegetation treatment receiving no potash so far and which showed the highest average of potash leached. (Required difference for odds of 99:1 was 1.39 grams.) Compared with Treatment 1, the difference is 1.87 grams which represents 12.0 per cent of the potash applied. During the second period Treatment 6 lost 3.29 grams more than Treatment 1, or 21.1 per cent of the potash applied, making the total loss for the whole 90 days 33.1 per cent. This is undoubtedly a serious loss as compared with a 6.0 per cent loss of somewhat doubtful significance where cane was present.

Treatment 7 showed consistently smaller losses than 6, but the differences were not significant. Nor did Treatment 9 show a significant difference from Treatment 8, although the difference is in the direction to be expected from theoretical considerations. It is worthy of note that Treatment 8 showed significantly higher losses than the no-potash treatments, while Treatment 9 did not. In view of these considerations and of the fact that the same sort of thing was indicated on a smaller scale in the cane pots, there is strong indication that the carbonate was leached less than the chloride, but that the conservation of potash by its use was certainly not great enough to warrant applying potassium carbonate at a higher cost than the neutral potash salts. Could a source of carbonate of potash be found which would supply it at a cost comparable to or only slightly higher than the other potash fertilizers, its use would probably result in a small saving of potash.

Treatment 8B did not show significantly smaller losses than did 6A, but the difference was in the direction to be expected. Treatment 9B, however, showed a significantly smaller loss than 7A. Treatment 9B did not show significantly

lower losses than 1A and 1B (the difference required is 1.01 in both cases), but Treatment 7A showed very much greater losses than either 1A or 1B. In the case of Treatments 8B and 6A, much the same situation existed since the difference between 8B and 1A or 1B, while significant, is much smaller and much less reliable than that between 6A and 1A or 1B. Therefore, it seems possible to conclude that delaying the application of potash until after nitrification was completed resulted in lesser potash losses in the case of the no-vegetation pots.

In general it can be said that, except in the case of potassium carbonate applied after nitrogen, the no-vegetation pots receiving potash suffered very much greater losses of potash than did the cane pots. This demonstrates that utilization of applied potash by the cane crop is very rapid and efficient, surprisingly so, when it is remembered that the first potash application was only 14 days after the previous crop had been harvested. At this time there was very little aerial system developed by the crop. It is interesting to note that during the first period the no-vegetation pots which had received no potash (Treatments 8 and 9) lost very little more potash than did the cane pots (Treatments 1, 4 and 5), and that the amounts leached are all greater than the amount of potash (0.165 gram) which was originally present in the tap water which passed through the soil. This would indicate that a sort of equilibrium was set up with the water which had to be satisfied without regard to the presence or absence of cane. This does not imply that the cane was taking up no potash, since considerably more water had to be applied to the cane pots in order to keep their leachates comparable in volume with those from the no-vegetation pots and the additional potash which went on in this water was available to the plants.

It should be emphasized that the rapid utilization of potash herein indicated applies only to a ratoon crop where an extensive root system has already been established.* This experiment does not enable prediction of potash losses from plant cane, but it can be assumed that they would be greater. In plant crops the use of nitrate fertilizers together with potassium carbonate until the root system had become extensive might result in considerable potash conservation. Such practice would probably be justified on acid soils with respect to potash conservation, provided the carbonate could be obtained at a price to compare favorably with the muriate or sulfate. This is demonstrated by the data from the no-vegetation pots which show that, except in the case of the carbonate applied after nitrification was complete, the applied potash was very inefficiently taken up by the exchange complex of the soil. It is evident that with acid soils the base-exchange complex can not be relied upon for retention of potash from neutral salts and that in the absence of an extensive root system serious losses of fertilizer may occur.

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* Obviously, the conclusions herein suggested do not apply to acid soils which have been subjected to heavy rainfall within a few days after receiving applications of fertilizers containing potash. Under such conditions, leaching losses might be very great. It also is quite possible that, under similar circumstances, losses by leaching might be very considerable on a non-acid soil of reasonably high effective exchange capacity due to runoff of water from the surface and to channeling through the soil profile. Such losses would probably be as great with respect to applied nitrogen and might be considerable with respect to phosphate applications.

With respect to the problem of eventual serious damage to our soils from the use of acid-forming nitrogenous fertilizers through loss of effective exchange capacity and therefore ability to retain potash, these data indicate that while an acid soil is a poor retainer of potash, a ratoon crop of cane even shortly after harvest is a very good retainer of potash. Hence, it appears that the use of acid-forming fertilizers is unlikely to constitute a menace to our soils from this standpoint so long as they are cropped to cane. Nor, need the release of potash already present in the exchange complex of a soil resulting from the application of acid-forming fertilizer materials be considered a loss unless it results in luxury consumption, since it seems highly probable that it will be taken up by the crop. However, savings in potash applications might be effected with soils containing a good supply of exchange potash by making simple laboratory determinations of the amounts of potash released from such soils during nitrification, and decreasing the potash amendments to be applied by the amounts indicated. Such practice would tend to decrease potash losses due to luxury consumption by the cane.

In view of the fact that sugar cane thrives in acid soils and that, should the amounts of calcium, magnesium and the so-called "less essential" bases ever reach a dangerously low level due to use of acid-forming materials, they can be supplied economically in quantity necessary for plant nutrition, it appears that there is insufficient reason at present to discourage the use of these materials.

The demonstratedly poor retention of applied potash by the exchange complex of an acid soil, together with the efficient uptake by the cane, indicates that applications of potash to such soils in quantities in excess of the crop needs will probably fail to build up the potash reserve of the soil and will result in loss due to luxury consumption by the crop. It seems likely that even in a non-acid soil the cane would tend to take up more of the excess than the soil and that such a policy would result in waste of fertilizer.

Summary and Conclusions

In ratoon cane pots, potash applied as either neutral salt or carbonate was not leached to any serious extent.

When potash was applied to cane pots at the same time as sulfate of ammonia was applied, significantly greater leaching of potash did not result than took place in pots which did not receive potash until nitrification was complete.

Somewhat lower losses of potash were indicated in uncropped pots which did not receive potash until after nitrification had taken place.

No important conservation of potash was gained by the use of the carbonate in cane pots.

Lower losses of potash were indicated by the use of the carbonate in uncropped pots.

Retention of applied potash by an acid soil in the absence of vegetation was poor, but in the presence of cane was very good, indicating highly efficient uptake of potash by ratoon cane.

This experiment indicated that seriously increased losses of potash by leaching as a result of long continued use of acid-forming fertilizers would be unlikely to occur in soils cropped to cane.

It was indicated that potash applied in excess of crop needs to an acid soil would probably fail to build up the reserve of exchange potash.

Literature Cited

(1) Allan, F. E., and Wishart, J., 1930. A method of estimating the yield of a missing plot in field experimental work. Journ. Agr. Sci., 20: 399–406.

(2) Ayres, A. S., 1939. The availability of insoluble phosphates to sugar cane. The Hawaiian Planters' Record, 43: 45–56.

(3) Eckart, C. F., 1906. Lysimeter experiments. Bul. 19, Agr. and Chem. Series, Expt. Stn. H.S.P.A.

(4) Gow, Paul L., 1931. A rapid method for the determination of potash. The Hawaiian Planters' Record, 35: 401–409.

(5) Hill, L. A., 1903. A colorimetric method for the determination of small quantities of potassium. Jour. Amer. Chem. Soc., 25: 990–992.

(6) Martin, J. P., 1935. Studies on growth of sugar cane in nutrient solutions. The Hawaiian Planters' Record, 39: 79–96.

(7) Morgan, M. F., 1936. Soil changes resulting from nitrogenous fertilization. Conn. Agr. Expt. Stn., Bul. 384: 371–449.

(8) Peck, S. S., 1911. Lysimeter experiments. Bul. 37, Agr. and Chem. Series, Expt. Stn. H.S.P.A.

Disease Control and Stimulation of Cane Cuttings by the Hot-Water Treatment

By J. P. Martin and R. K. Conant

Inasmuch as the hot-water treatment was first used experimentally in the Territory for the control of chlorotic streak disease and more recently as a plantation practice for stimulating the germination and early growth of cane cuttings, it seems advisable to present the subject matter in this paper in two parts. The first part which deals with disease control has been prepared by J. P. Martin while the second part which concerns a plantation practice has been written by R. K. Conant.

Disease Control by the Hot-Water Treatment

The most effective control of any disease is the substitution of resistant varieties. The selection of healthy planting material is also highly efficacious for maintaining a low incidence of many diseases, especially in localities where environmental conditions favor their development and spread. Other of the more important measures of control are: roguing diseased plants, sterilization of cane knives, creating conditions favorable for cane growth, weed control, and more recently the hot-water treatment.

Sugar cane diseases such as gumming, leaf scald, and Sereh have been effectively controlled in other countries by the hot-water treatment. In experiments conducted here and elsewhere no control of mosaic has been secured by the treatment; no effect on the disease was evident even when diseased cuttings were immersed in water at temperatures from 52 degrees to 56 degrees C. for intervals from 10 minutes to 2 hours. At the higher temperatures and longer intervals cane growth was greatly depressed. However, at the lower temperatures and shorter intervals a stimulation in germination and cane growth resulted.

Chlorotic streak disease was first recognized in 1929 on POJ 36 at Olaa Sugar Company, Ltd., and since that time it has been found on all the Islands and on a large number of cane varieties. In pot studies pertaining to the disease at the Pathology plot it was established in October 1930 that symptoms of the disease failed to develop from cuttings of POJ 36 which were selected from diseased plants and given the hot-water treatment prior to planting.

In cooperative studies with R. K. Conant in relation to the field control of the disease, two small observational tests were installed in November 1930 at Olaa wherein diseased cuttings of POJ 36 were subjected to the hot-water treatment. Of the various temperatures, and intervals of exposures to such temperatures, the most satisfactory treatment proved to be 52 degrees C. for 20 minutes; in almost every instance this particular treatment has given 100 per cent control of the disease in cane cuttings. In these first experiments a definite growth response was apparent from the hot-water treatment (Fig. 1). Following the 1930 experiments many pot and field tests have been conducted on Oahu and Hawaii in relation to the cause and control of chlorotic streak and the response of varieties to the hot-water treat-

Fig. 1. Showing the effect of the hot-water treatment (52 degrees C. for 20 minutes) on cane cuttings of POJ 36 affected with chlorotic streak disease. Left, plants from healthy cuttings. Center, plants from diseased, treated cuttings. Right, plants from diseased, untreated cuttings. Note the superior growth from the diseased, treated cuttings (center).
—*Photo by Conant.*

Fig. 2. Chlorotic streak disease is controlled in cane cuttings by the hot-water treatment. Left, cane growth resulting from diseased cuttings of 31–2806 following the hot-water treatment. Right, cane growth from diseased, untreated cuttings of 31–2806.—*Photo by Conant.*

Fig. 3. Hot-water unit for treating cane cuttings installed in 1931 at Makiki.

ment, the results of which have demonstrated that the disease, in so far as it is carried by cuttings, is controlled by the treatment (Fig. 2), and that the germination and early growth of most varieties are stimulated. It should be stated that with a few varieties the treatment resulted in depressed growth.

Following the appearance of chlorotic streak disease on canes at Kailua substation, it was deemed advisable to subject all cuttings to the hot-water treatment prior to shipment to plantations and regional stations; in order to carry out this procedure a hot-water unit (Fig. 3) was constructed in 1931 at the Makiki station. The water in the large tank is heated and maintained at 52 degrees C. by steam, and to insure a uniform temperature the water is circulated by a centrifugal pump. Immediately following the treatment, the cuttings are placed in a tank of cold water, as shown in the extreme left of Fig. 3, to prevent possible injury from prolonged heating. Since it was later found to be more economical to treat and pack cane material for shipment at Kailua substation, a hot-water unit was installed there in 1934.

The tanks first used for treating large quantities of cane cuttings were constructed with redwood but later it was found that large metal tanks could be used to advantage. The size of the tank depends on the quantity of material to be treated; some of the first tanks were 4 feet wide, 6 feet long, and 5 feet deep, while the metal tanks now in use at Waipio and Kailua substations are somewhat larger.

After considering the advantages of the hot-water treatment in relation to additional ways and means for excluding foreign cane diseases and insects with imported cane material, the Quarantine Committee in 1931 adopted the practice of subjecting to the hot-water treatment all cuttings of imported cane varieties upon their arrival

into the Territory and all cuttings of varieties released from the Molokai Quarantine Station.

In 1931, C. E. Pemberton demonstrated that all observed insects, either within or on cane cuttings were killed at an exposure of 52 degrees C. for 20 minutes. In the Director's Monthly Report for August 1933, Mr. Pemberton states: "In cooperation with the Agriculture department, a test was completed to determine a satisfactory hot-water treatment for cane cuttings shipped as seed from Anomala territory to plantations outside its known distribution. Living Anomala adult beetles were bagged with cane seed having dry cane leaves for packing and the entire package immersed in water at 50 degrees C. for 30 minutes. No beetles survived this treatment and we understand this degree of heat for 30 minutes is not harmful to the cane seed. In the future, this will be the standard treatment for all cane seed shipped from Anomala infested fields to other localities in Hawaii." Since that date (1933), when a hot-water unit was completed at Waipio, all cane material shipped from Waipio has received such treatment (50 degrees C. for 30 minutes).

In recent years Ceresan, an organic mercury compound, has been found by staff members of plantations and this Station to be the most effective disinfectant for treating the freshly cut ends of sugar cane cuttings for preventing the entrance of organisms which, under wet and cold climatic conditions, often cause a rotting and souring of the cuttings. The cut ends are dipped in a one per cent (by weight) solution of Ceresan. The directions regarding the application of Ceresan and its effectiveness are summarized in a circular letter by the Genetics department dated February 27, 1939. Ceresan apparently does not stimulate germination *per se* but a superior growth results since it prevents the entrance of rot-producing organisms which play a major part in poor germination.

Hot-Water Treatment of Cane Seed

The stimulating effect on germination, produced by treating cane seed in various ways prior to planting, has often been discussed in the literature. Soaking cane seed in cold water from 24 to 48 hours is an old method of treating cane seed and has been used successfully by plantations in the Hawaiian Islands for many years. The addition of lime to the cold water is said to further hasten germination of the seed. Soaking cane seed for one hour in water treated with acetylene gas has also been found to stimulate germination of certain varieties. More recently a method in which the freshly cut ends of seed pieces are dipped into a one per cent Ceresan solution has been used quite widely. The senior author of this paper found that treating cane seed in hot water at 52 degrees C. for 20 minutes resulted favorably in controlling chlorotic streak disease. He also found that this treatment hastened germination and stimulated growth. These methods of treating cane seed have been tried experimentally at Olaa Sugar Company, and the cold- and hot-water treatments have been used on seed planted to field-scale proportions.

The results of experimental work in cooperation with Mr. Martin on the chlorotic streak disease problem at Olaa Sugar Company left no doubt as to the value of treating seed with hot water under conditions on this plantation, not only in relation to chlorotic streak disease, but also as a practical means of hastening germination, stimulating growth, and reducing cultivation costs in plant cane. Therefore,

Fig. 4. Hot-water unit used at Olaa Sugar Company for treating cane cuttings. The tank is 12 feet x 12 feet x 6 feet deep with a capacity of 6463 gallons. The tank can handle 100 bags of seed at a time. The small, inexpensive loading machine is operated by a 6-horsepower, one-cylinder gasoline motor. This unit is able to treat 2000 bags per day with 4 men assisting in the work at a cost of less than one cent per bag. Additional transportation costs involved in trucking the seed to and from the unit brings the total cost for hot-water treating of seed to about one cent per bag.—*Photo by Conant.*

Fig. 5. Showing the method used at Olaa Sugar Company for piling the bags into rope slings preparatory to handling with the small loading machine shown in Fig. 4.—*Photo by Conant.*

this method of treating cane seed was developed to a point where large quantities of seed can now be handled with ease, and today all seed at Olaa Sugar Company is given this treatment prior to planting. The unit shown in Fig. 4 was built to handle the hot-water treating of seed, and has proven very satisfactory. This unit can handle 2000 bags per day, but during the planting season so far this year 1000 to 1500 bags per day have been sufficient to take care of the planting requirements. Four men working 8 hours a day can attend to piling 1000 bags into slings as shown in Fig. 5 and assist in the work in general. A careful check is kept on the temperature of the water which is not allowed to vary more than 2 degrees (50 degrees C. to 52 degrees C.). The water is heated by means of steam which enters through a perforated 1-inch pipe at the bottom of the tank. When the maximum temperature of 52 degrees C. is attained, the steam is shut off and about 100 bags of seed are lifted into the tank, 10 bags at a time in slings as shown in Fig. 4. The temperature is maintained by allowing steam to enter slowly during the 20 minutes the bags are being treated.

When it is convenient to do so the bags are piled in slings on the trucks that transport the seed to the hot-water unit, thus saving one step in the handling of the seed.

Experiments at Olaa Sugar Company have indicated that it is unnecessary to dip seed in cold water following the hot-water treatment, and that the temperature may vary between 50 degrees C. and 52 degrees C. and the time between 20 and 25 minutes without altering the results. These details may seem of minor importance, but they have a bearing on the method when considering treatment of seed on a large scale. If it is permissible to use the leeway in time and temperature mentioned, and plant the seed without dipping in cold water following the hot-water treatment, then the method becomes much easier to adopt for practical purposes.

The hot-water treatment has a tendency to soften the eyes and unless precautions are taken to prevent mechanical injury to the eyes, poor stands may result from hot-water treated seed. This applies particularly to body seed, since the eyes of body seed, unlike the eyes of top seed, are not protected from mechanical injury by the leaf sheath. Various ways of handling body seed have been tried at Olaa Sugar Company with indications that the simplest and most effective method is to insist that the seed cutters leave the trash on the stalks and seed pieces, and when bagging the seed to place a little trash in the bags with the seed. The trash protects the eyes from mechanical injury.

During the first 6 months of 1939, 60,000 bags of seed have been hot-water treated at Olaa Sugar Company at a cost of about one cent per bag. From previous experience we are quite certain that this small additional planting cost will be more than offset by reduced cultivation costs for weed control, brought about by the stimulation in growth due to the treatment.

A comparison between 1 per cent Ceresan-treated and hot-water treated seed is shown in Fig. 6. The variety in this test is 31–2484 planted 21 days before the photograph was taken. The test is located in a mauka field, elevation 1650 feet, where conditions are everything but favorable for rapid germination. The seed planted in the C plot on the right was treated with a 1 per cent Ceresan solution in the usual manner by dipping the freshly cut ends of the seed pieces into the solution.

Fig. 6. Showing a comparison between hot-water treated seed (HW) at the left and Ceresan-treated seed (C) at the right. Photograph taken 21 days after the seed was planted. Cane variety 31–2484, elevation 1650 feet. The cane shoots in the HW plot can be easily seen, whereas the shoots in the C plot do not show up in the photograph since they were only commencing to penetrate the mulch paper at the time the photograph was taken. A plot which adjoins the C plot, but not shown in the photograph, was planted with untreated seed, and after 31 days no signs of germination could be seen in this plot. No signs of germination could be seen in this untreated plot until 5 weeks after planting.—*Photo by Conant.*

The seed in the HW plot on the left which was planted on the same day, was given the hot-water treatment, viz., soaked in hot water at 52 degrees C. for 20 minutes. A count was made in this test of the number of shoots that had germinated and penetrated the mulch paper in 21 days. The data are given below:

Plot	No. ft. of row	No. shoots	Plot	No. ft. of row	No. shoots
HW	100	73	C	100	35
HW	100	73	C	100	17
HW	100	78	C	100	6
HW	100	106	C	100	2
HW	100	99	C	100	13
Total	500	429	Total	500	73
Average	100	86	Average	100	15

The average height of the shoots in the HW plot 21 days after planting was 12 inches against 3 inches for the shoots in the C plot.

A check plot not included in the photograph was planted with untreated seed on the same day. This plot adjoins the C plot and after 21 days no signs of germination could be seen. All plots in this test are ½ acre in size, and were planted for observational purposes.

The plant fields at Olaa Sugar Company are doing exceptionally well this year despite the unusually cold and wet weather that has prevailed and slow and poor

Fig. 7. Showing portion of a field of 32–1063, 6 weeks after planting. Note the full, vigorous stand obtained from hot-water treated seed. Elevation of this area is 1650 feet where annual rainfall usually exceeds 200 inches, and average maximum temperatures rarely exceed 73 degrees F. and average minimum temperatures are seldom above 61 degrees F.

—*Photo by Conant.*

germinating canes have germinated rapidly with full stands even when planted at high elevations. Fig. 7 shows 32–1063 plant at 1650 feet elevation 6 weeks after having been hot-water treated and planted.

Discussion:

At present the stimulating effect from the treatment is not understood. However, it is believed to stimulate certain chemical and enzymic changes within the cuttings which are normally associated with germination. Another theory is that the treatment may increase the rate of cell division of the meristematic cells in the lateral buds and accelerate those physiological processes (absorption, respiration, etc.) accompanying growth.

It is interesting that the hot-water treatment should be so effective for controlling chlorotic streak disease and at the same time for stimulating the germination and early growth of sugar cane cuttings.

Where chlorotic streak is a problem or when questionable planting material is to be used, it is recommended that such material be treated in order to secure healthy planting material. As an aid for better germination, especially at the higher elevations where environmental factors are less favorable for cane growth, it is hoped that the heat treatment will be used or at least be experimentally tested with different varieties under various conditions.

A growth response immediately following planting, as already pointed out, reduces weeding and cultivating costs and insures a more uniform stand of cane. The

sooner a cane plant establishes its own shoot roots and becomes independent of the original cutting, the better chance it has for competing against adverse environmental factors and for maintaining a normal growth. An uneven growth of plant cane under cold and wet conditions has been caused at times by rot-producing organisms attacking cane cuttings prior to and during germination; the use of Ceresan has aided greatly in protecting cuttings from such attacks. Any treatment that will hasten the germination of sugar cane cuttings will make for better growth and lower field costs.

Evaporation of Moisture From Soil in Large Lysimeter Pots

By P. L. Gow

While conducting a lysimeter experiment on the leaching of potash from a soil, it was found necessary to determine the daily water consumption of the pots used in the experiment. The water consumption was calculated as the difference between amounts of water applied to each pot by irrigation and rainfall, and amounts of water collected as drainage. The experiment required the inclusion of 16 lysimeter pots which were kept free of all vegetation. Since the water consumption of these no-vegetation pots seemed to indicate that considerable quantities of water were removed from the soil by evaporation, contrary to certain established ideas with respect to soil-water relationships, these data were deemed worthy of reporting.

The general experimental layout is described elsewhere.* The lysimeters consisted of cubical concrete pots 2 x 2 x 2 feet, which had received three coats of hot asphaltum to prevent leakage. The entire layout consisted of 36 pots arranged in 4 rows of 9 pots each. The pots were buried to ground level and between each pair of rows was a sunken concrete runway which provided for collection of drainage. The drainage from each pot was received in an especially constructed 5-gallon tin can, the inlet of which had a diameter of 1.5 inches so that evaporation from the cans was minimized. The soil used was a free-draining, acid Manoa soil, which had been air-dried, screened and well mixed before placing in the pots. Pots containing cane alternated with no-vegetation pots.

Water received as rainfall was measured by means of a standard rain gauge. Water applied as irrigation was weighed on a solution balance sensitive to 1 gram. Drainage was measured by weighing the cans which contained water, emptying and re-weighing the empty cans for tare. One gram of water was considered as equivalent to 1 c.c. and water data were recorded as cubic centimeters.

All pots were fertilized alike with respect to nitrogen and phosphorus. Potash fertilization was varied.* All pots had contained sugar cane which was allowed to develop until several nodes of millable stalk showed above ground. The cane was then cut back to the seed piece in the no-vegetation pots so as to remove all points from which new growth might start. The no-vegetation pots were kept free of weeds throughout the time that drainage was collected.

Immediately after the cane had been cut and before the collection of drainage data reported in Table II had begun, it was noticed that the water consumption from all pots was very appreciable. To test whether this was due to evaporation, 12 of the 36 pots were covered with crudely fitted cardboard covers. The data presented in Table I show the water consumption of each pot during the 24-hour period following. The results from this rough experiment are taken to indicate

* Gow, P. L., 1939. A Lysimeter Study of Losses of Applied Potash by Leaching from an Acid Soil. The Hawaiian Planters' Record, 43: 263–276.

that the water consumption was chiefly due to evaporation. It is probable that the water which disappeared from the covered pots was also evaporated, since the covers were by no means tight.

TABLE I

COMPARISON OF WATER CONSUMPTION OF COVERED AND UNCOVERED POTS

Covered	Uncovered	
c.c.	c.c.	c.c.
1078	2846	2524
1059	2700	2491
783	2704	2106
626	2518	2359
1103	2561	2503
853	2529	2341
723	2919	2150
813	2802	2149
953	2507	2246
772	2352	2411
735	2503	2261
562	2093	2188

Table II presents the average water consumption data from the no-vegetation pots. Drainage measurements were made the morning of the day following irrigation, the latter having been applied in the late afternoon so that the pots would still be draining at sundown. Thus, daily consumption data are calculated on the assumption that each pot had a definite water-holding capacity and that evaporation reduced the water held below this level. The difference between water applied in the afternoon and water drained next morning was taken as water consumed the previous day.

Occasionally, the drainage pipes of one or more pots became stopped and were not freed until next day. These stoppages were always indicated in the drainage data, and drainage figures from such pots were discarded in calculating the average consumption figures until it was certain that normal drainage had been re-established. Thus, the data presented contain no values known to be abnormal due to stoppage of drains. Twice, due to heavy rainfall, and once, due to some unknown cause, drainage data from all pots were considered unreliable, so no data for the periods August 3–4, August 9–10 and August 24 have been reported.

TABLE II

Date	Average total c.c.	Average total inches	Average daily inches	Date	Average total c.c.	Average total inches	Average daily inches
1938				August			
June				8	2369	0.25	0.25
25–26	4500	0.48	0.24	9–10	....	....	....
27	3630	0.38	0.38	11–15	10799	1.14	0.23
28	3199	0.34	0.34	16	3918	0.41	0.41
29	2227	0.24	0.24	17–19	2154	0.23	0.08
30	1770	0.19	0.19	20–21	4375	0.46	0.23
July				22	2404	0.25	0.25
1–4	6719	0.71	0.18	23	2577	0.27	0.27
5	2740	0.29	0.29	24	....	....	....
6	2620	0.28	0.28	25	952	0.10	0.10
7	2977	0.32	0.32	26–28	7580	0.80	0.27
8	3055	0.32	0.32	29–30	4516	0.48	0.24
9–10	2847	0.30	0.15	September			
11	2247	0.24	0.24	31–1–2	7581	0.80	0.27
12	1996	0.21	0.21	3–5	6447	0.68	0.23
13	2972	0.31	0.31	6	3373	0.36	0.36
14	3274	0.35	0.35	7	1240	0.13	0.13
15	2942	0.31	0.31	8	2465	0.26	0.26
16–17	4310	0.46	0.23	9	2845	0.30	0.30
18	3034	0.32	0.32	10–11	2173	0.23	0.12
19	2461	0.26	0.26	12	2198	0.23	0.23
20	4114	0.44	0.44	13	2452	0.26	0.26
21	2297	0.24	0.24	14	2151	0.23	0.23
22	1972	0.21	0.21	15	1704	0.19	0.19
23–24	4878	0.52	0.26	16	2368	0.25	0.25
25	3946	0.42	0.42	17–19	6173	0.65	0.22
26	2738	0.29	0.29	20–21	5166	0.55	0.27
27	3251	0.34	0.34	22	2730	0.29	0.29
28	4413	0.47	0.47	23	1831	0.19	0.19
29	4452	0.47	0.47	24–25	4645	0.49	0.25
30–31	3367	0.36	0.18	26	1386	0.15	0.15
August				27–28	3643	0.39	0.19
1	2132	0.23	0.23	29	2163	0.23	0.23
2	2849	0.30	0.30	October			
3–4	....	....	....	30–1–2	4833	0.52	0.17
5	2451	0.26	0.26	3–4	4694	0.50	0.25
6–7	4363	0.46	0.23	5–6	4341	0.46	0.23

Table III presents average total consumption figures for successive 30-day periods.

TABLE III

Period	No. of days	Average total consumption, inches
1938		
June 25–July 24.............	30	7.72
July 25–August 23..........	30	6.61*
August 24–September 22.....	30	6.79*
September 23–October 6.....	14	2.93
	104	24.05

* Data for 4 days in the period July 25–Aug. 23 and for 1 day in the period Aug. 24–Sept. 22 are missing. If these missing figures are estimated as equivalent to the average daily consumption for the periods, the totals become 7.63 inches and 7.02 inches, respectively. The total for the entire 104 days becomes on this basis 25.30 inches. This procedure is probably not justified in the period July 25–Aug. 23 since the missing figures are due to heavy rainfall, during which evaporation would be expected to be low.

Discussion of Data

Since the data presented in Table I appear to show that water consumption of these no-vegetative pots was due to evaporation, consumption data will be considered as evaporation hereinafter. Most of the days during this experiment were hot and sunny. On such days, the surfaces of the pots became completely dry to a depth of at least one-half inch by 10:00 A.M. with the exception of one pot, the surface of which for some unknown reason never became dry. This pot drained well and its consumption data showed no significant difference from that of the other 15 pots. Evidently this was a case in which water moved upward in the soil due to capillary action. In the case of the other pots, most of the water lost by evaporation must have moved up from the lower soil levels as water vapor since the surface soil was dry most of the time evaporation took place.

That the high rate of evaporation showed by these pots was not entirely due to the fact that they were usually irrigated daily is demonstrated by the data for periods when the pots received no irrigation for several days. Average daily evaporation in inches for July 1–4 was 0.18 inch. During the period only 0.02 inch of rain fell. During the period August 11–15, the average daily evaporation was 0.23 inch. The rainfall was: August 11, 0.12 inch; August 13, 0.11 inch, and August 15, 0.02 inch. The data from these and other periods when the pots did not receive daily irrigation indicate that, while the average daily evaporation tended to be somewhat lower during these periods, it was comparable with the evaporation when the pots were irrigated daily.

The author is not qualified to draw any general conclusions concerning soil-water relationships from these data. They were secured during the progress of an experiment designed entirely for other purposes and are presented here only in the hope that they may be of interest to workers in the field of soil irrigation.

Sugar Prices

96° CENTRIFUGALS FOR THE PERIOD
JUNE 21, 1939 TO SEPTEMBER 15, 1939

Date	Per pound	Per ton	Remarks
June 21, 1939........	2.81¢	$56.20	Philippines, 2.80, 2.82.
" 22.............	2.85	57.00	Philippines.
" 27.............	2.87	57.40	Philippines, 2.85; Puerto Ricos, 2.86, 2.90; Cubas, 2.90.
" 28.............	2.90	58.00	Philippines, Puerto Ricos.
July 5.............	2.93	58.60	Puerto Ricos, Philippines.
" 11.............	2.85	57.00	Puerto Ricos.
" 14.............	2.84	56.80	Philippines.
" 20.............	2.90	58.00	Cubas.
" 21.............	2.88	57.60	Philippines.
" 24.............	2.90	58.00	Puerto Ricos.
" 25.............	2.92	58.40	Cubas.
" 26.............	2.90	58.00	Philippines.
Aug. 7.............	2.85	57.00	Philippines.
" 8.............	2.82	56.40	Cubas.
" 9.............	2.80	56.00	Cubas.
" 15.............	2.82	56.40	Philippines.
" 16.............	2.83	56.60	Philippines.
" 22.............	2.80	56.00	Puerto Ricos.
" 25.............	2.90	58.00	Philippines.
" 31.............	2.92	58.40	Puerto Ricos.
Sept. 5.............	3.75	75.00	Philippines.
" 6.............	3.81	76.20	Cubas, 3.76, 3.81, 3.86.
" 7.............	3.80	76.00	Cubas, 3.79, 3.81.
" 8.............	3.85	77.00	Philippines.
" 13.............	3.60	72.00	Philippines.
" 14.............	3.70	74.00	Philippines.
" 15.............	3.60	72.00	Philippines.

THE HAWAIIAN PLANTERS' RECORD

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